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RESEARCH ARTICLE

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Toward a notation for modeling value driver trees: Classification development and research agenda

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Abstract

Value driver trees (VDTs) are abstract, indicator-based representations of a business model. Although they are conceptual models by nature, no systematic and unified approaches to their modeling exist to date. In fact, a heterogeneous understanding of their conception and methodological implementation has been established. The goal of this study is to provide more clarity in this regard by examining the semantics (the question of "what?") and syntax (the question of "how?") with respect to VDT modeling. For this purpose, a structured literature review was conducted in which a collection of 161 VDTs was evaluated. Based on an extended taxonomy design process, the typical model constructs of VDTs were extracted. As a result, a so-called *VDT Model Classification* was derived, which structures 34 model constructs into three dimensions with eight categories. This classification establishes a clearer understanding of the model constructs and their representation, thereby providing a conceptual framework for a unified and more substantiated "vocabulary" for VDT modeling. Finally, a research agenda has been formulated that generally addresses the role and future application potential of VDTs and, in particular, describes the next steps toward a sound notation for modeling VDTs.

KEYWORDS
classification, conceptual modeling, literature review, value driver tree, value-based management, visual notation

1 | INTRODUCTION

Value driver trees (VDTs) are established tools for value-based management (VBM) (Koller et al., 2020). They provide decision-makers with a deep understanding of an individual business model by reconstructing and visually representing its inherent causal relationships in value generation (Ferreira & Otley, 2009; Wall & Greiling, 2011). Specifically, VDTs represent a systematic method for the analytical explication of logical cause-effect chains between (a) financial (value-oriented) results and (b) their performance-oriented (monetary as well as nonmonetary) determinants—so-called "value drivers" (VDs). Such VDs are central performance indicators to be managed and are basically characterized by the fact that they are derived from the individual business model, have a significant influence on a higher-level result variable, and can be influenced to a considerable extent by the company (Koller, 1994; Rappaport, 1987, 1998). Because of this potential for creating transparency and focus, VDTs are regarded as a proven management tool for handling the complexity in today's business world (Diana, 2021).

Although the concept of VDTs has existed for many decades, it is currently experiencing a certain "renaissance" due to digitalization (Anantharaman, 2018; ICV, 2017; Valjanow et al., 2019). Accelerators of their growing relevance are the current availability of large amounts of data (Wobst et al., 2023), which has long been the biggest obstacle to the comprehensive and effective implementation of VDTs (Klauck et al., 2015), as well as advanced information technologies and analytical capabilities (Anantharaman, 2018). However, it is not only the introduction of VDTs that is being driven by digitalization, but, conversely, VDTs are also seen as an enabler for the digitalization of accounting and finance (Brosig et al., 2019; Fähndrich, 2023). VDTs provide a construct for modeling accounting and financial data in the form of a logical system by enabling strong data-driven, statistical mapping of systemic cause-and-effect relationships of business models (Wobst et al., 2023). In this way, they serve as the necessary information model for the implementation of many digitized use cases of modern accounting and finance applications. Specific use cases are, for example, computer-aided business simulation and optimization (Klauck, 2015; Valjanow et al., 2019), predictive forecasting (Schnegg & Möller, 2022; Valjanow et al., 2019), and advanced management reporting (Federmann et al., 2020; Visser, 2020). Another example is the integration of artificial intelligence (AI), for example, for performing probabilistic simulations and optimizing performance indicators, or for automated interpretation and commenting on identified business developments (Gupta et al., 2022; Kiron & Schrage, 2019). However, to enable such use cases of modern and automated accounting and finance practices, these technologies must first be provided with a computational concept that teaches them the interrelationships of the business model to understand the inherent cause-and-effect relationships and ultimately the consequences of decisions (Visser, 2020). VDTs are such calculable representations of business models. The correspondingly growing practical relevance of VDTs (Demyttenaere et al., 2023) is also evident from the fact that established tools for enterprise planning and analysis—such as SAP Analytics Cloud (see Gole & Shiralkar, 2020)—are facilitating the implementation of VDTs.

Despite all VDT potentials, there are also common development problems and implementation hurdles. In particular, the initial modeling of VDTs involves challenges with respect to (1) model construction and (2) model representation (Koller et al., 2020; Wall & Greiling. 2011; Weber et al., 2017): (1) If irrelevant indicators are modeled or connections are incorrectly constructed, useless cause-effect relationships will be established. (2) If VDTs are unsystematically presented in terms of content, scope, and structure, their communication and, ultimately, their understanding will be impeded (Akkiraju & Zhou, 2012; Wall & Greiling, 2011). These fundamental problems of VDT modeling are also driven by the fact that a heterogeneous understanding of VDTs has developed over the years, and no basic modeling standards exist (Weber et al., 2017). Nevertheless, these obstacles should be addressed in a well-founded way when modeling VDTs because VDTs—if developed unsystematically—are otherwise deprived of their "decision-facilitating purposes" (Wall & Greiling, 2011, p. 100). It has been repeatedly confirmed that the way indicators and their contextual relationships are presented have significant impact on managers' ability to interpret them and make effective decisions (see Belle et al., 2022; Farrell et al., 2012; Ittner et al., 2003; Kahneman et al., 2016; Nowotny et al., 2022). Therefore, logical and proven systematizations of VDT modeling are needed (Nørreklit et al., 2006).

The motivation of this research is to contribute to a better understanding of systematic VDT modeling. The central idea is that systematic modeling of VDTs benefits from having a generic modeling language, or "vocabulary," that provides more clarity about typical model constructs (in the sense of building blocks), as well as their visual representation in a model. The following chain of arguments underlies this research idea:

1 First, *VDTs are conceptual models*: Conceptual models are, by definition, "an abstraction or representation of relevant concepts in an aspect of the physical world" (Nwokeji et al., 2018, p. 4634). Such abstractions support communication and understanding of complex knowledge (e.g., information and contexts) (Clark et al., 2015; D. Moody, 2009). The nature of VDTs corresponds precisely to this definition. VDTs are "a visual representation of a conceptual business model that links a business value [. . .] to a set of drivers" (Anantharaman, 2018).

2 Second, *conceptual models need a modeling language*: Only comprehensive and standardized rules of representation enable a systematic development and generally understandable communication of conceptual models (Clark et al., 2015; D. L. Moody, 2005; D. Moody, 2009). Corresponding modeling languages "employ predefined constructs and mostly a visual notation to represent real-world phenomena in a certain domain" (John et al., 2017, p. 4). The benefits of a standardized modeling language have been widely confirmed and include validity,

efficiency, and reliability in the design and interpretation of such models (Burton-Jones et al., 2009; Indulska et al., 2009; Paige et al., 2000).

3 Finally, *VDTs do not have a modeling language*: VDTs are intended to enable a common understanding of a business model (Koller et al., 2020). However, a common understanding requires a common language. Following from the previous argument, a well-founded and generally understandable modeling language is necessary for this. However, VDTs as a form of conceptual models have no such language. Based on the experience with other modeling languages, it can be expected that an appropriate language can improve the design as well as interpretation of VDTs.

The research objective is to create more transparency about the options for VDT modeling, which can then form the basis for the development of a systematic modeling language (i.e., notation set). In the process of developing a suitable notation set, however, basic building blocks of semantics (that is, the generic model constructs to be represented) and syntax (i.e., the representation of the model constructs) must first be defined with respect to modeling VDTs. By defining these elements, VDT designers would receive guidance on which contextual model constructs could be integrated as building blocks into a VDT model and how they could be visualized in a standardized way. Such clarity would also simplify subsequent interpretation by VDT users. Accordingly, in order to gain transparency into the practice of VDT modeling and thereby advance it, the research question (RQ) is as follows:

> *RQ: What are the common constructs in modeling VDTs, and how can they be represented?*

To answer this RQ, an extensive literature review was conducted, and a total of 161 VDTs were analyzed. The analysis was performed using the *extended taxonomy design process* (ETDP) according to Kundisch et al. (2021). Following a design science research approach (Hevner et al., 2004; Peffers et al., 2007), a conceptual framework in the form of a "*VDT Model Classification*" was then derived, which structures 34 model constructs of a VDT into three dimensions with eight categories. These model constructs can be understood as generic building blocks with which companies can model their individual VDTs in a systematic and standardized way, regardless of which specific indicators, relationships, or structures they want to depict. The corresponding contribution of this research is twofold. First, by defining specific model constructs in a conceptual classification, a clearer understanding of the content and representation of VDTs is established. This can guide the modeling of VDTs but also provide a conceptual foundation for the development of a corresponding modeling language (i.e., notation set). Second, based on the knowledge gathered in the research process, which is based on an extensive analysis of the VDT literature, a corresponding research agenda is defined on the one hand, and specific recommendations for the modeling practice are formulated on the other.

This research paper is organized as follows: Section 2 first outlines the theoretical foundations (i.e., the basics of VDTs as well as modeling languages) before specifying the research gap (i.e., modeling VDTs). Section 3 describes the research design (i.e., the literature review and classification development processes). Section 4 shows initial results of the literature review. Section 5 introduces the VDT Model Classification. Section 6 explains the related research agenda. Section 7 offers a concluding discussion of the central contributions, implications, limitations, and an outlook on further research paths.

2 | RESEARCH BACKGROUND

2.1 | VBM and value driver

VBM is a management approach with a long history (see Ittner & Larcker, 1998; Rappaport, 1986) and an active discourse (Malmi & Ikäheimo, 2003; Wobst et al., 2023). At its core, VBM is driven by the goal of consistent value creation at companies (Ittner & Larcker, 1998; Rappaport, 1986; Koller et al., 2020; Koller, 1994). It can be defined in this regard as a "management system that [. . .] enables the organization to be focused, measured and compensated based on its ability to create value for its stakeholders" (Beck & Britzelmaier, 2011, p. 203). To ensure such holistic management of a firm's value generation, Copeland et al. (2000) describe VBM accordingly as an integrative process aimed at improving strategic and operational decisions at all levels of the organization by focusing common efforts on the targeted steering of value-creating activities. Although the actual contribution of VBM is still controversially discussed in research (Malmi & Ikäheimo, 2003; Wobst et al., 2023), several studies indicate a positive effect on managerial decision-making (Firk et al., 2021) and ultimately on company performance (Firk et al., 2016; Lueg & Schäffer, 2010).

However, the positive effect of VBM needs to be systematically developed. As a basic principle, the VBM approach suggests that management can only rely to a limited extent on financial outcome indicators when making value-creating decisions. Pure financial outcome indicators are too generic and highly aggregated to allow a consistent link between strategic and operational planning and control. Moreover, their outcomes are manifested due to previously made business decisions (Firk et al., 2016; Ittner & Larcker, 1998, 2003). Therefore, as part of the integrative VBM process, the highly aggregated financial outcome indicators must therefore be traced back to the factors that influence them in the first place: the "value drivers" (VDs). The underlying logic is that a positive development of a VD leads—ceteris paribus—to an increase in the subsequent financial outcome variable (Copeland et al., 2000). For example, profit is calculated from the financial variables of revenue and costs, whereby the latter in turn results from, for example, labor costs, material costs, and overhead costs, which in turn are a result of their individual VDs to be influenced by the company, such as the productivity of the employees or the rejection rate (see Kaufmann, 2020; based on Koller, 1994). Consequently, to be able to control profit in a target-oriented way, steering has to start several stages before at the relevant VDs. Based on this basic logic, VDs should help management to develop strategies, allocate resources and set financial targets in a targeted manner, thereby supporting the underlying objectives of value generation (Firk et al., 2016).

However, although the term VD is old (Rappaport, 1986) and has become part of common usage, it is still not possible to clearly define or classify it. As with the term "value[1]," there is still only a very weak understanding in the literature of what is meant by the widely used term VD (see Kaufmann, 2020; Wobst et al., 2023). Koller (1994, p. 91) describes a VD generally as "any variable that affects the value." Ittner and Larcker (2001, p. 353) provide a more specific description with reference to the business performance perspective, describing it as "the specific performance variables [. . .] that actually create value." Following these generic definitions, this study will consider a VD to be any performance variable that can be influenced/controlled by the company and that is capable of positively influencing the value or, more generally, the benefit of a stakeholder in a significant way (see also Wall & Greiling, 2011). To get a more profound idea of the nature of VDs, Ittner et al. (2003) outline various business topics with a number of exemplary VDs, such as operational performance (e.g., productivity), product and service quality (e.g., defect rates), or product and service innovation (e.g., development cycle time). For companies that prioritize ecological goals, environmental indicators (e.g., carbon-efficiency) can also represent value-creating VDs for their business model (Figge & Hahn, 2013; Lisi, 2015).

[1] The term "value" is interpreted very heterogeneously in the literature. In the narrower sense, according to Rappaport (1986), it can be understood as "shareholder value," which stands for the value (monetary worth) of a company to be maximized from the equity owners' point of view. In a broader sense, value creation can also be understood as the fulfillment of a general stakeholder's requirement(s) (see Harrison & Wicks, 2013; Wall & Greiling, 2011). For example, environmental, social, and governance (ESG) aspects are also increasingly being considered as key indicators of value creation that need to be managed (Figge & Hahn, 2013; Lisi, 2015; Schramade, 2016). For the purpose of this study, this broader, generic description will therefore be referred to.

2.2 | Conception of VDTs

As described above, the integrative VBM approach requires that VDs be linked to financial performance measures in a causal context to help management better understand the impact of decisions. In fact, the clear availability of information on value drivers is an essential prerequisite for the success of the VBM implementations (Burkert & Lueg, 2013; Nowotny et al., 2022). Therefore, the use of what Ittner et al. (2003, p. 725) describe as "performance measurement alignment techniques" is necessary to build an understanding of how VDs are embedded in the business model, how they interact, and how they causally affect financial outcomes (Abernethy et al., 2005). As such, VDTs (often also referred to as value driver hierarchies, maps, or models) are a proven technique for the operationalization of the integrative VBM approach with VDs (Ittner et al., 2003; Koller et al., 2020; Wall & Greiling, 2011). Their relevance arises from the need to create a holistic view that clearly integrates the financial outcome indicators and their causal influencing variables—the VDs—in a holistic system. The essential idea is that "the value creation process can be described (and managed) by a linear additive model" (Speckbacher et al., 2003, p. 364). VDTs are thus an abstracted and indicator-based system of a certain business model, which is composed of cause-and-effect relationships between the strategic (financial) target indicators of the company and their underlying operational performance indicators that can be managed by the company (Koller et al., 2020). In this way, VDTs break down controllable VDs to the more detailed levels of the organization, creating a manageable system of indicators. Hahn and Kuhn (2011, p. 1) describe their role accordingly: "value driver trees are prevalent frameworks of VBM to measure and analyze [. . .] value creation."

A standard formal theoretical definition of VDTs does not exist in the literature. Nevertheless, to create a consistent understanding of VDTs for the further course of this study and at the same time to account for the broad and quite heterogeneous application of VDTs, they shall be defined as follows (based on Anantharaman, 2018; Koller et al., 2020):

> *A value driver tree (VDT) is a tree-like visual representation of a conceptual business model that links a business value (the indicators that*

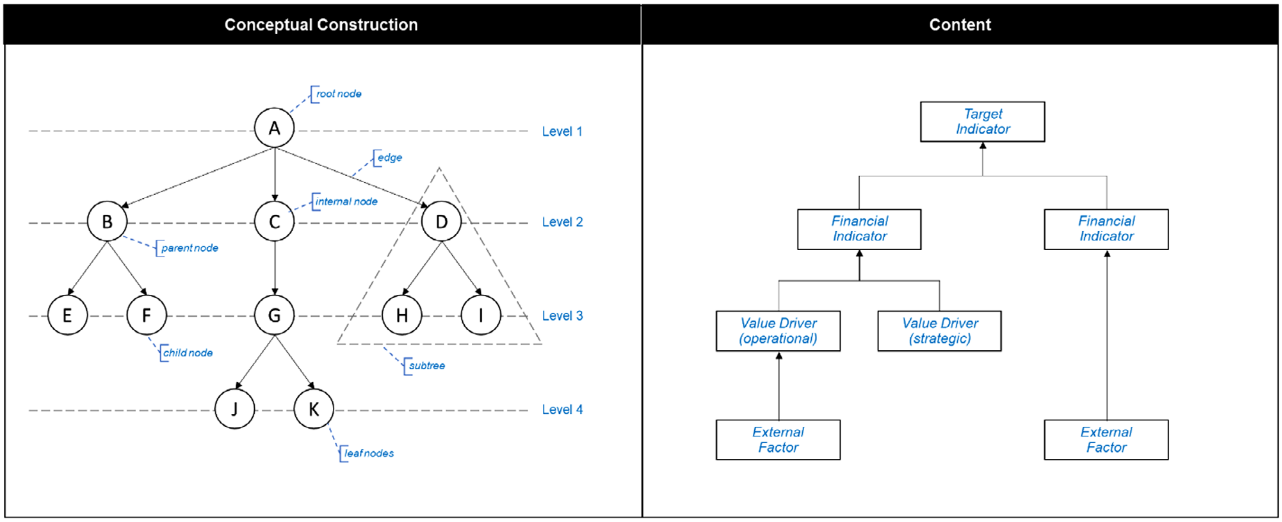


FIGURE 1 Conceptual construction and content of VDTs.

> *are important to management and stakeholders) to the underlying value drivers (VDs; the key performance indicators that can be influenced by the management to maximize the business value).*

Based on this generic definition, the conceptual characteristics of a VDT will be elaborated even more explicitly to clearly understand the requirements for its modeling. Although there is no common understanding, the conceptual characterization of VDTs can be done from two perspectives, (1) the conceptual construction and (2) the content of VDTs (see Figure 1):

1. The conceptual construction of VDTs is strongly based on the definition of tree representations as data models (see, e.g., Schulz, 2011; Storer, 2002). According to this, VDTs can be understood as hierarchically directed graphs, consisting of a set of nodes and their connecting edges. Three derived conceptual characteristics will be taken up here accordingly: (a) *nodes*, (b) *edges*, and (c) *tree organization*.
    a. *Nodes*: VDs are usually multilayered within an organization. Therefore, a VDT is hierarchically structured. The tree structure used for this purpose is already apparent from its name. Classical tree structures (rooted trees) visualize the hierarchical relationship of elements (so-called nodes) in branches that divide them up. A given top element (root node) is followed by intermediate elements (internal nodes) and, at the lowest level, bottom elements (leaves). The direct relationship between two linked elements is expressed by the terms parent node (the node closer to the root) and child node (the immediately following node farther from the root). Accordingly, each node can be either a data source or a calculated result. This way, in VDTs, a hierarchical indicator system is created, which successively splits the value-oriented target indicator (root node) into its increasingly detailed sub-indicators (internal nodes) and monetary and nonmonetary influencing factors (leaves) so that ultimately, the direction of the cause-and-effect chain becomes explicit.
    b. *Edges*: By definition, the manipulation of a child node's value will influence the connected parent nodes' values. Each parent node is, therefore, a result of one or a combination of its children's nodes. In this context, edges visualize corresponding connections of parent and child nodes. Edges can be visualized explicitly (by means of clearly drawn links) or implicitly by means of their positioning in a certain structure (e.g., by means of an ordered sequence or grouping). In VDTs, such effect relationships of nodes can thus be linked formally (mathematically) or logically (assumed, subjective cause-effect relationships). Usually, the upper branches of the VDT can easily be split exactly, formal-mathematically, from the top target figure (root node) with the directly splittable financial partial results (internal nodes). However, this becomes increasingly difficult in the subsequent hierarchy levels of the VD (further internal nodes or leaves), which can be connected either by basic mathematical operators or more by logical associations. Of course, from a management perspective, relationships that can be clearly calculated mathematically are generally less problematic and less uncertain (Ashton, 2007).

c. *Tree organization*: The simple visualization of relationships is a core feature of VDTs. However, the complexity of the tree visualization increases with the number of elements and their relationships. Pulay and Simon (2020) emphasize, for example, that VDTs lose their clarity already after the fourth branching (i.e., levels). With increasing complexity, it is therefore often advisable to organize VDTs by means of structuring elements (e.g., subtrees) so that the tree structure continues to organize the relationships in a meaningful way and thus represents them transparently.

2. The conceptual content of VDTs essentially defines what is represented in the model by means of nodes. In VDTs, these nodes can be understood as their building blocks, with which the individual indicators to be modeled can be represented. In general, indicators can be interpreted very broadly. In practice, there is a multitude of indicators that play a role in the value generation of a company. For the purpose of systematic modeling of VDTs, it is thus necessary to concretize the broad understanding of this set of indicators. A generic, widely used but certainly not generally valid distinction is to differentiate indicators of a VDT according to (a) target indicator (end result), (b) financial indicators (partial results), (c) influencing VDs (strategic or operational), and (d) external factors (see Weber et al., 2017):
   a. *Target indicator*: At the top of a VDT is the target indicator (i.e., key result), usually in the form of a value expressed in financial terms. By means of the VDT, the factors influencing this value are identified and arranged according to their interrelationships.
   b. *Financial indicators*: Financial target indicators (e.g., profit) can usually be broken down directly into financial sub-indicators (intermediate or partial results, such as revenues and costs, the latter in the next hierarchical level into labor, material, and overhead costs). Such intermediate financial results of a target indicator are characterized by the fact that they themselves are also the result of an upstream business performance (i.e., they cannot yet be directly controlled by the company). Rather, this is possible through managing the upstream VDs (e.g., the employee's productivity or the rejection rate). In general, an essential characteristic of financial indicators is that they are primarily derived from the data source of financial accounting.
   c. *Value drivers (VDs)*: "The very nature of value drivers is a causal relation" (Wall & Greiling, 2011, p. 99). VDs are fundamentally characterized by the fact that they are factors of business performance that have a significant influence on the overriding (financial) value and can be influenced by a company in a targeted manner. Accordingly, Rappaport (1998, p. 171) describes them as "leading indicators of value." In this context, VDs can represent both monetary (e.g., advertising expenditure) and nonmonetary factors (e.g., customer satisfaction) or—distinguished from another perspective—directly measurable, quantitative (e.g., on-time deliveries) as well as indirectly measurable, qualitative (e.g., customer satisfaction) factors. As a consequence, VDs have a significant and direct influence on financial values and precede the actual financial realization as leading indicators of these values (i.e., financial results are lagging indicators). In the literature, a distinction is often made between operational and strategic VDs (Weber et al., 2017). Operational VDs represent known factors influencing value generation, which can be controlled considerably by the company in the context of performance steering. Strategic VDs, on the other hand, represent new and, therefore, less well known influencing factors, such as the development of new business areas or the impact of internal optimization measures, which should also be considered due to their long-term influence.
   d. *External factors*: Factors from the economic, political, or social environment (e.g., exchange rates, market growth, changes in legislation) can also influence the economic development of a company. Such factors are characterized by the fact that they can hardly be influenced by the company itself but nevertheless have an impact on its value generation and ultimately on the target indicators.

2.3 | Conceptual models and modeling languages

Complexity can be a significant obstacle to decision-making. Abstractions are necessary to reduce the complexity of the real-world in which we operate, such as the business context, and to make it manageable. Conceptual models are corresponding abstractions that represent a relevant concept of the real-world (Clark et al., 2015; D. L. Moody, 2005). In this respect, conceptual models can be used to represent a variety of concepts, such as business models (see Roelens & Poels, 2015), business processes (see Recker et al., 2010), or data (see Parsons & Wand, 2008).

Modeling languages are needed to express conceptual models in a systematic and universally understandable way (Clark et al., 2015; D. Moody, 2009). To abstract and represent a real-world phenomenon systematically, modeling languages define a collection of constructs—usually in the form of a visual notation—and a set of rules on how to connect these constructs (D. Moody, 2009; Wand

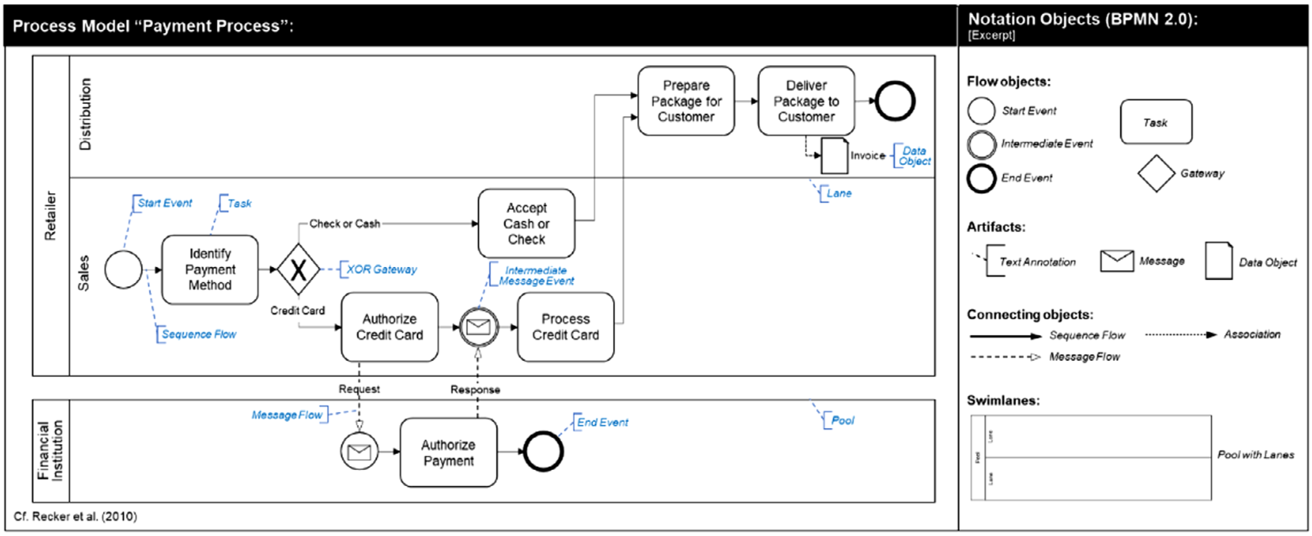


FIGURE 2 Exemplary process model "payment process" (BPMN 2.0).

& Weber, 2002). In this way, modeling languages fulfill the important purpose of standardization (D. Moody, 2009; Paige et al., 2000). The description of a business process, for example, a payment process (see Figure 2), would always be expressed differently without a standardized form of representation, which makes its communication and understanding much more difficult and may finally lead to errors in the execution of the process.

There are basically two characteristics that describe a modeling language (Burton-Jones et al., 2009; D. Moody, 2009; Wand & Weber, 2002): *semantics* (the question of "what?") and *syntax* (the question of "how?"). "Semantics" of a modeling language define the semantic constructs required to fully represent a real-world phenomenon (D. Moody, 2009). An example: the semantic constructs used to describe a process are the "process start," "tasks," and "process end" (John et al., 2017). "Syntax" of a modeling language defines the form of visual representation of the corresponding semantic constructs (Burton-Jones et al., 2009; D. Moody, 2009). In the form of a visual notation set, graphical symbols are defined for the representation of each individual semantic construct. For example: a thin black circle may represent the "process start," an oval box a "task," and a bold black circle the "process end" in a process model (John et al., 2017).

Figure 2 shows an example of the definition and use of such a modeling language. Using the established *Business Process Modeling Notation* (BPMN 2.0) (BPMNI.Org and OMG, 2006), a model of a payment process is shown (see Recker et al., 2010). On the right-hand side is a section of notation objects, which define the semantics (constructs) and syntax (visual representation of the constructs) of the modeling language (e.g., "process start," "tasks," and "process end"). Using this "vocabulary," the business process (left side) can be mapped in a standardized way.

2.4 | Related research and research gap

With respect to the conceptual modeling of VDTs, the semantics and syntax in terms of their model constructs have not yet been clarified. There are related modeling languages or notations, but they do not fulfill the specific modeling purpose of a VDT. This modeling purpose is—based on the VDT definition in Section 2.2—to represent a business model by mapping its significant indicators and their interrelationships. Accordingly, the modeling purpose can be summarized based on two characteristics that are required for the intended use of VDTs: (requirement 1) the conceptual, tree-like representation of cause-effect relationships (mathematical but also logical) between (requirement 2) target indicators and the influencing (monetary or nonmonetary) VDs of a specific business model. Using these two requirements, the utility of related modeling languages is evaluated in the following.

Although some modeling languages are related to the purpose of mapping a business model, they do not meet the defined modeling requirements of an indicator-based representation. For example, there are languages for modeling business models, such as the *Value Delivery Modeling Language* (VDML) (see Roelens & Poels, 2015), but they do not focus on the representation of indicators in their business model representations (requirement 2), but rather on "real-life" constructs, such as relevant organizational units and specific activities. Furthermore, languages exist for modeling key performance indicators (KPIs), such as by Maté

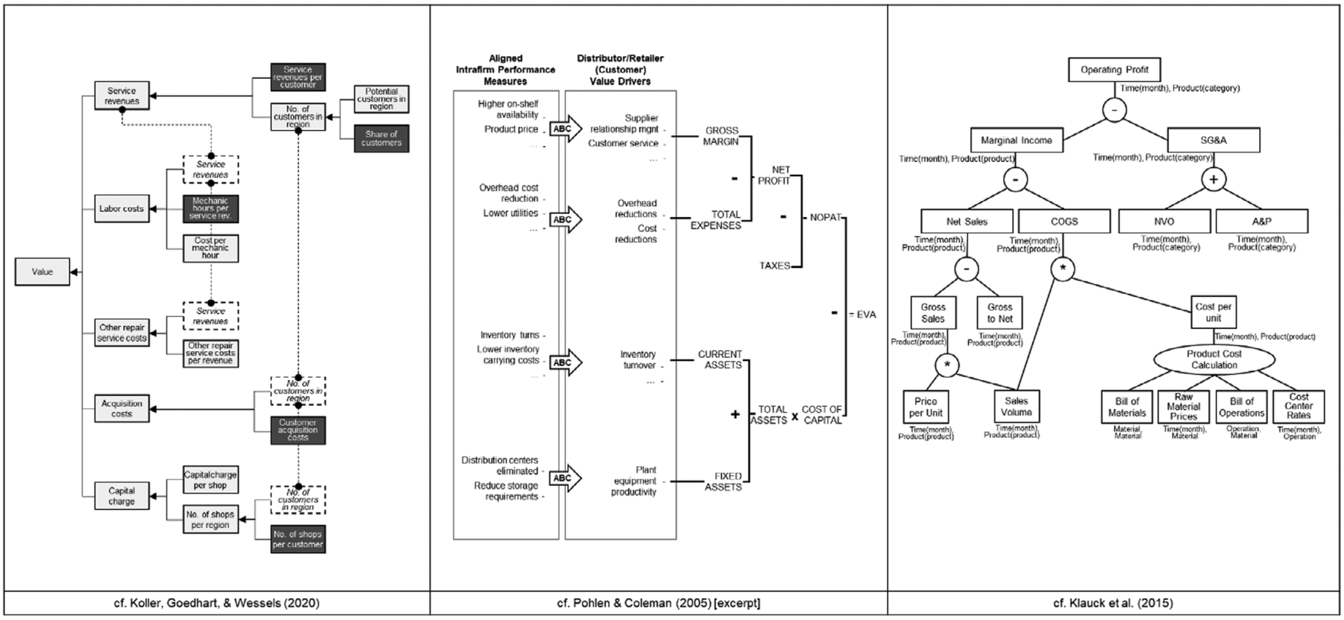


FIGURE 3 Exemplary VDT models.

et al. (2016). However, such languages primarily fulfill the purpose of data modeling, that is, achieve a conceptual transformation of data into KPIs (e.g., using the constructs to be modeled such as "name," "unit," "decomposition," or "formula"). The indicator-based mapping of a business model (requirement 2) and its tree-like representation of relationships (requirement 1) is not the primary purpose.

This lack of standards has led to a huge variety of representations of VDTs. To give an impression, Figure 3 shows three different examples, which already provide an idea of the variety of modeling forms. Although all models follow a tree structure (requirement 1) and show the relationships between a target indicator and its influencing VDs (requirement 2), there is nevertheless a strong variation in the representation. This becomes particularly evident when looking at the varying implementation of the conceptual characteristics outlined in Section 2.2—the nodes, edges, and tree organization.

The resulting research gap can be justified as follows. First of all, it is known that business decisions are made in a managerial reality that must first be constructed by logics and communication modes (Seal, 2012). In this regard, Belle et al. (2022) confirm that the way performance indicators are presented has a significant impact on the ability to make sense of them. This requires clarity and ease in the readability of indicators and their corresponding context. Correspondingly, it has been confirmed that the benefits of systematic VBM can only be fully realized if the causal relationships of VDs can be understood and clearly communicated (Burkert & Lueg, 2013; Farrell et al., 2012; Nowotny et al., 2022). However, these requirements are accompanied by the well known problem that human decision-making in such a managerial reality is flawed by interpretation and variability in judgment (Hammer, 2019; Kahneman et al., 2016). Common reasons for this are a lack of guidance in interpretation due to a lack of context or too much and poorly presented information (Hammer, 2019). All this makes the cognitive effort in decision-making harder. For this purpose, the concept of pragmatic constructivism (Nørreklit et al., 2006) suggests the creation of solutions that generate shared intelligence about a decision-making context (Seal, 2012). Conceptual modeling languages can undoubtedly be regarded as such a solution. The benefits of systematic and standardized conceptual modeling languages have already been widely researched and confirmed in other domains (see Burton-Jones et al., 2009; Indulska et al., 2009; Paige et al., 2000). Designers of conceptual models benefit from systematic guidance in the creation of the models, which not only makes the design more efficient and complete (Burton-Jones et al., 2009), but also stimulates thinking and ultimately enriches the model contextually (Bodker, 1998). Users of conceptual models benefit from consistent communication and a guided understanding of how to read such models in their interpretation. Ultimately, this also supports interpretational validity, efficiency, and reliability in the use of conceptual models (Burton-Jones et al., 2009). Therefore, it can be argued that the design, communication, and understanding of VDTs can also benefit greatly from standardized and context-rich modeling guidance. However, this involves aspects beyond the basic conceptual framework described in Section 2.2. For example, the possible options of integrating managerial context (e.g., responsibilities) or creating structure (e.g., levels) in

VDT models are still unresolved. Therefore, an examination of the semantics in the sense of their model constructs and the syntax in the sense of their representation is necessary in order to gain more clarity about the possible modeling options. Something that is mentioned in the literature as worthwhile research in the context of accounting and financial management (Fähndrich, 2023; Wobst et al., 2023). The practical relevance of a more systematic approach in the modeling and use of VDTs is emphasized in the following argument by Fähndrich (2023, p. 27): "It is not enough to have basic knowledge about the business model in question. Rather than that, management accountants need to put business models and their value drivers into a meaningful context." Therefore, this research gap is addressed in this study.

3 | RESEARCH DESIGN

3.1 | Literature review

In order to gain a structured insight into the broader practice of VDT modeling, a literature review was conducted as proposed by Webster and Watson (2002) and Vom Brocke et al. (2009). The design of the literature review is based on the six characteristics (I-VI) of Cooper's (1988) taxonomy: the (I) *focus* of the review is on the practices or applications in modeling VDTs. The (II) *goal* is to integrate these practices and applications in a structured overview. Specifically, the semantics and syntax of modeling will be summarized in a generic classification with model constructs. In the context of this summary, a neutral (III) *perspective* is taken. The (IV) *coverage* of the review is based on a representative, though certainly not exhaustive, collection of published VDTs (see Figure 4). The search of the review focuses primarily on publications of conceptual VCT models rather than empirical studies of their use, which is consistent with the goal of the study. The scope of the search included both scholarly (peer-reviewed) and practical (e.g., white papers) sources. The complete reference list can be found in the supplementary material (Table S2). The (V) *organization* of the review is focused on a systematic ordering of constructs in the modeling of VDTs (see Section 3.2 on the process of classification development). The (VI) *audience* of the review is researchers and practitioners in the field of VBM and its methods.

The five steps (1-5) of the corresponding literature review process are summarized in Figure 4. The (1) *initial search* attempted to provide the broadest possible access to scientific and practice-oriented publications. A full-text search was performed in nine sources (scientific literature databases and search engines) using a search string that checks the occurrence of synonymous terms of VDTs (e.g., VDT/model/hierarchy/system). In total, 445 potentially relevant publications were identified. These went through a (2) *initial review* to check whether they actually contained an individually modeled and fully documented VDT. In this step, 352 publications were excluded. Based on the remaining 93 publications, a further (3) *reference (forward/backward) search* was performed, as recommended by Levy and Ellis (2006). This identified 28 additional publications. The (4) *final collection* thus comprised 121 publications from which a total of 161 VDTs could be extracted for the review. The (5) *final coding* of the identified VDTs was performed using the ETDP according to Kundisch et al. (2021) (see Section 3.2). As a result of the literature review, a classification of constructs commonly used in VDT modeling was developed, and insights into the VDT modeling practice were also gained. In summary, a well-founded research agenda was outlined based on the extensive analysis of the VDT literature.

3.2 | Classification development

In its essence, this study is based on the goals and practices of design science research (DSR), which is a research paradigm that seeks to scientifically develop innovative artifacts that improve the capabilities of people and organizations (Hevner et al., 2004; Peffers et al., 2007). Corresponding artifacts can be, among others, "constructs," which stand for language concepts (e.g., vocabularies or symbols) that can be used to describe domain-specific problems or to specify their solutions (e.g., the modeling of VDTs). In line with this DSR approach, the 161 available VDTs were analyzed to design a structured classification[2] of the inherent model constructs and their representation. For this purpose, the ETDP, according to Kundisch et al. (2021), was applied (see Figure 5). The ETDP (an evolution of the method developed by Nickerson et al., 2013) is a systematic and transparent method to conceptualize a given phenomenon into dimensions and characteristics. According to the ETDP (Kundisch et al., 2021), a total of 18 steps

[2] There is a broad understanding of the partly synonymous terms "classification," "framework," "typology," or "taxonomy" (see Nickerson et al., 2013). A "classification" – in the sense of this research – is a general term for a multidimensional ordering of entities into groups or classes on the basis of their similarity (according to Bailey, 1994). However, such a classification has to be distinguished from the common understanding of a more specific "taxonomy" (Nickerson et al., 2013). A central characteristic of a taxonomy is, besides others, the mutual exclusivity restriction, which means that an object cannot be assigned to two different characteristics in one dimension. However, this characteristic is not fully applicable to the classification developed here. A VDT can certainly be assigned to two constructs of the same dimension. Therefore, the term broader classification is used in the following.

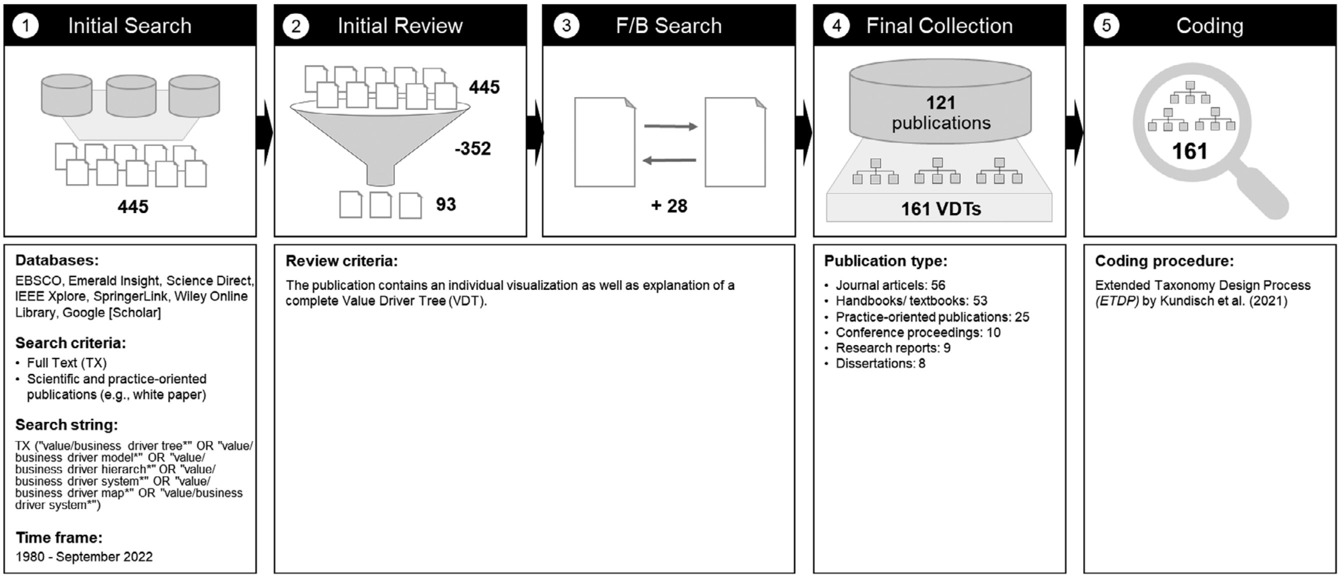


FIGURE 4 Literature review process.

(1-18), some of them iterative, were performed in six phases (I-VI).

I. *Identify problem and motivate*: (1) The phenomenon to be studied is VDT modeling, specifically, the understanding of the model constructs and their representation used in the process. (2) The target audiences are researchers and practitioners in the field of VBM. (3) The purpose of classification is to systematically organize model constructs into meaningful dimensions and categories. The classification is intended to be a conceptual framework on the way to a more unified and more substantiated “vocabulary” for VDT modeling.

II. *Define objectives of a solution*: (4) *Meta-characteristics* of the classification were defined to provide a first basic framework for the assignment of constructs (as suggested by Nickerson et al., 2013). Since VDTs are fundamentally based on the concept of a tree structure, the corresponding characteristics of trees as a data structure (see Section 2.2) were used to define overarching dimensions (nodes > “Indicators,” edges > “Connections,” and “Structure”). (5) The definition of ending conditions has the purpose of being able to identify the successful end of the iterative analysis process. In accordance with Nickerson et al. (2013), the following *objective ending conditions* were defined for the development process: (a) all representative samples (i.e., 161 VDTs) have been examined; (b) at least one sample is classified under each construct of each dimension; (c) no new dimensions or constructs were added in the last iteration; (d) no dimensions or constructs were merged or split in the last iteration; (e) each dimension is unique and is not repeated; and (f) each construct is unique within its dimension. In addition, the classification should also fulfill *subjective ending conditions* (the classification should be concise, robust, comprehensive, extendible, explanatory) (see Nickerson et al., 2013).

III. *Design and development*: (6) The development of the classification can be done as an empirical-conceptual or as a conceptual-empirical approach. In a *conceptual-empirical approach* (c), dimensions and constructs are conceptualized on the basis of expert knowledge (7c). The objects of investigation are subsequently examined along the predefined constructs (8c). In the case of an *empirical-conceptual approach* (e), a relevant subset of objects is first defined (7e), and common constructs are explored (8e), which are subsequently grouped in a meaningful way (9e). Accordingly, the present analysis conducted five iterations (see the results of the iterations in the supplementary material; Figures S1-S4). In the first iteration, a conceptual-to-empirical approach was chosen in which the predefined dimensions (e.g., “Indicators”) were extended by more specific (sub)categories (e.g., “Type”) based on the descriptions of Koller et al. (2020) (7c). Subsequently, ten objects from Koller et al. (2020) were classified along these dimensions and categories, and a first set of constructs (e.g., “Business Value Driver”) was derived (8c). As a result, an initial classification was developed (10) (see Figure A1). Three further empirical-to-conceptual iterations followed, in which further subsets of the VDT collection (7e) were first qualitatively coded to extract commonly appearing constructs (8e), then assigned

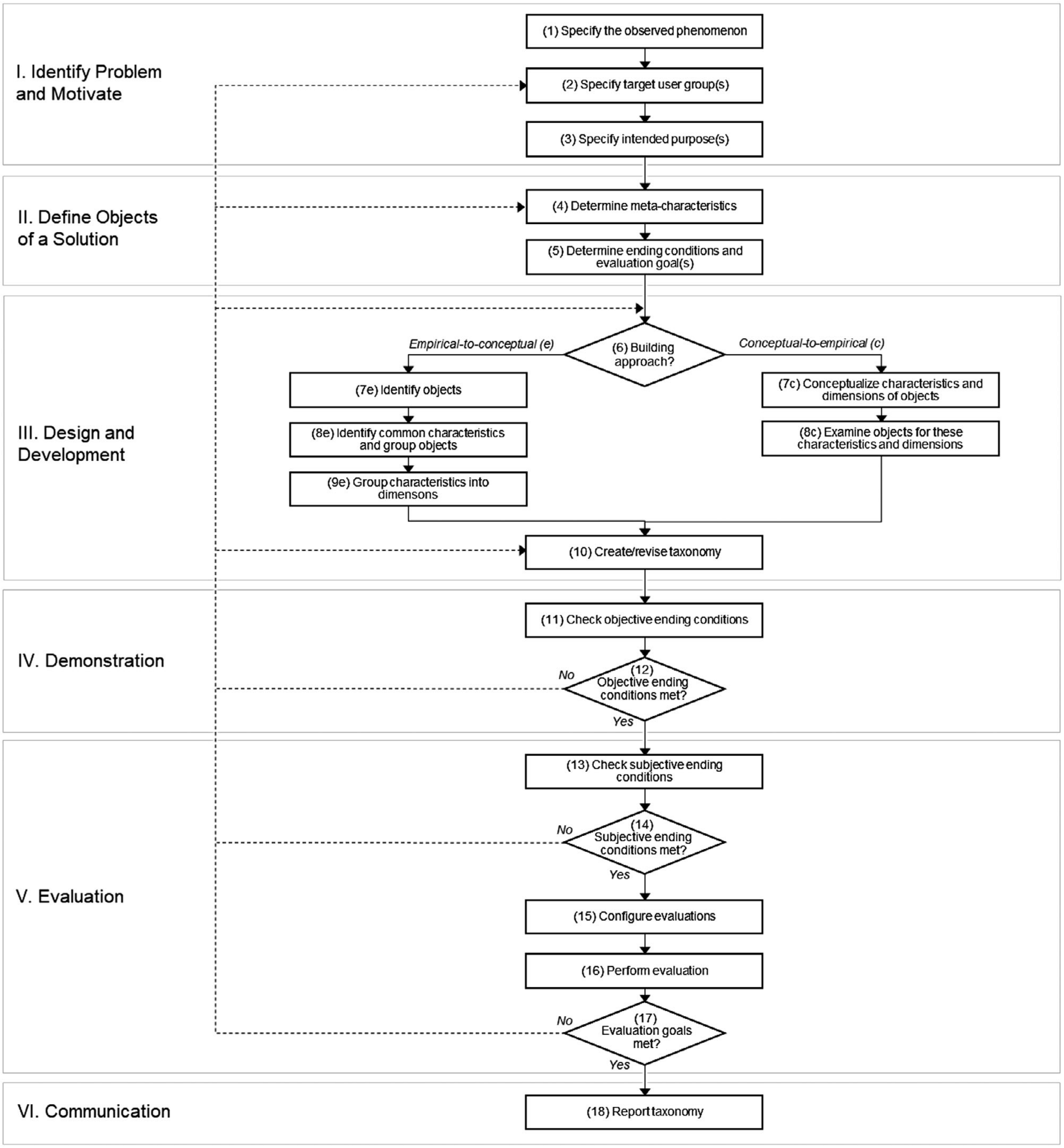


FIGURE 5 Extended taxonomy design process [ETDP] (cf. Kundisch et al., 2021).

to the previous status of the classification (9e), and finally, a revised, new status of the classification was developed (10). The corresponding revision included the addition, renaming, deletion, or merging of constructs (see Figures A2-A4). In a fifth and final iteration (empirical-to-conceptual), the classification developed so far was tested by coding the complete VDT collection (161 VDTs) according to the preliminary final constructs of the classification. As a result, the final version of the classification was established (see Figure 6). The complete coding results can be found in the supplementary material (Tables S1-2).

IV. *Demonstration*: (11) Based on the final version of the classification, the *objective ending conditions* were reviewed. These were met (12), as all objects of the sample were coded according to the developed classification (a), at least one object was assigned to each developed construct (b), and no new constructs

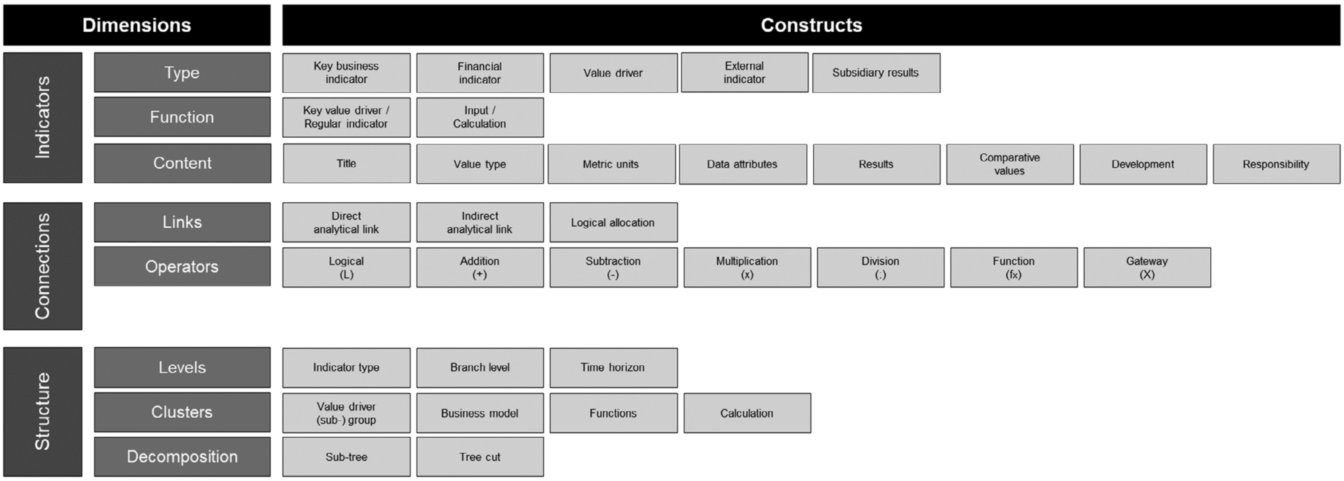


FIGURE 6 VDT Model Classification.

were added (c) or changed, and the dimensions and constructs were unique (d-f).

V. *Evaluation*: The *subjective ending conditions* (13) were initially evaluated in a round of three subject experts (two researchers and one practitioner). The classification was judged to be *concise*, that is, the number of dimensions and constructs is meaningful without being unwieldy or overwhelming; the classification is *robust*, that is, the dimensions and constructs allow sufficient differentiation among the VDTs under study; the classification is *comprehensive*, that is, all VDTs in the sample as well new VDTs can be classified in a comprehensive manner; the classification is *extensible*, that is, provides enough context for additional dimensions and constructs; the classification is *explanatory*, that is, provides in-depth starting points for understanding VDTs. In a further evaluation, the classification was used by means of a practical demonstration (15). Here, an example of a real-life VDT (see Figure S5 in the supplementary material) was remodeled using the classification (16). As a result, it could be practically demonstrated (see Figure 7) how a VDT modeling based on the defined constructs can, on the one hand, structure the representation of VDTs and, on the other hand, facilitate the interpretation and ultimately the understanding of VDTs (17).

VI. *Communication*: The communication (18) of the classification takes place with this publication.

4 | DESCRIPTIVE RESULTS

As a first step, descriptive insights into the characteristics of VDTs in practice were obtained from the review of the VDT collection (n = 161). First, the target indicators on which the VDTs are based were evaluated (see Table 1). In an inductive process of qualitative content analysis, nine content classes of target indicators were derived. Value-oriented target indicators (such as Economic Value Added®) were by far the most widespread, followed by profit or return-oriented indicators (such as operating profit or return on assets) and non-financial performance indicators (such as production volume or environmental performance factors). These results suggest that, on the one hand, the classical understanding of value in the sense of VBM is still at the center of the application of VDTs, but that, on the other hand, more common performance indicators are also implemented with VDTs. This confirms a rather broad understanding of "value" (see also Section 2.1) in the application of VDTs.

TABLE 1 Occurrence of target indicators by class.

Target indicator class	Occurence (#)	Share (%)
Value	71	44%
Profit	25	16%
Return	24	15%
Performance	20	12%
Cash flow	8	5%
Costs	8	5%
Interest	2	1%
Revenue	2	1%
Debt	1	1%
TOTAL	161	100%

Insights were also gained into the structure of the VDTs, that is, the number of modeled indicators and the number of branches in the tree representation (see Table 2). Here it was determined that VDTs are expressed with an average of 24 indicators, with a larger proportion of these falling on the cause-related value drivers (avg.: 14.1) than on the financial result indicators (avg.: 9.4). Comparatively few

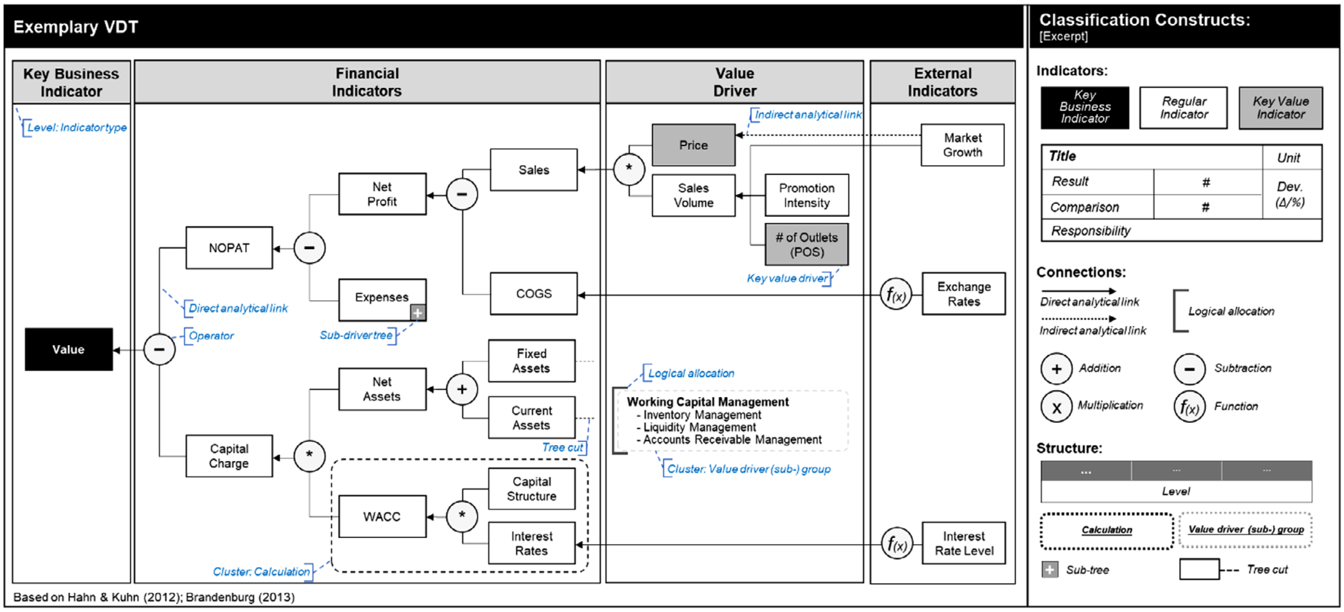


FIGURE 7 Practical demonstration of the VDT model classification.

TABLE 2 Descriptive statistics of VDT indicators and branches.

VDT content	Avg.	S.D.	Max.	Min.	Median
Indicators [total]	24	13.5	78	6	21
Financial indicators [no.]	9.4	8.8	78	0	8
Value driver [no.]	14.1	12	60	0	11
External indicators [no.]	.5	1.2	6	0	0
Branches [no.]	4.4	1.7	15	2	4
Indicator/Branch (avg.)	5.5	2.6	19.5	2	5

external indicators are included in the models (avg.: .5). In general, the average number of 24 implemented indicators can be described as feasible, as it is still manageable (see, e.g., Assiri et al., 2006). However, it should also be noted that the results show a large standard deviation (S.D.), which suggests that there is also a stronger deviation from a reasonable number of indicators. The same applies to the number of modeled branches, where a number of four is considered recommendable (Pulay & Simon, 2020).

5 | VDT MODEL CLASSIFICATION

The so-called "*VDT Model Classification*" (see Figure 6) was developed, which organizes the constructs typically modeled in a VDT and thus brings more transparency to VDT modeling for the first time. Basically, the classification is organized in a multidimensional structure. Three general dimensions reflect the typical construction of tree structures (nodes > "Indicators," edges > "Connections," and "Structure"), which are further specified on the basis of eight categories (e.g., "Indicators" according to "Type," "Function," and "Content"). Based on this structure, a total of 34 model constructs are arranged. Figure 6 is a synoptic representation of the corresponding VDT Model Classification designed along the ETDP (see Section 3). In the following, the meaning of the constructs organized in the classification is explained in more detail (see Tables 3–10).

5.1 | Indicators

Indicators are the key elements to be modeled in VDTs. An indicator can be understood as a specific measurement or expression of a condition that reflects a relevant aspect of value creation. As central modeling elements in VDTs, indicators' meaning and representation can be characterized using three categories: *type*, *function*, and *content*.

Type: The indicators modeled in a VDT can differ in several respects (Weber et al., 2017), such as their relation to the operative business and influenceability by the company, their temporal relation (leading vs. lagging indicators), or the degree of uncertainty. Thus, it makes sense in VDT modeling to be aware of these differences and to consider the indicator-based diversity of a company's management requires. The constructs outlined in Table 3 structure such a distinction, which is also largely based on a corresponding understanding of the literature (see Section 2.2). These generic constructs represent a kind of classified building blocks that can be used for

TABLE 3 VDT indicators—type.

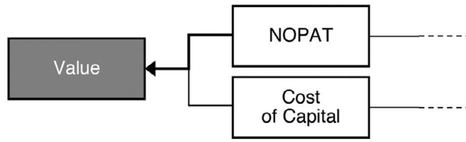
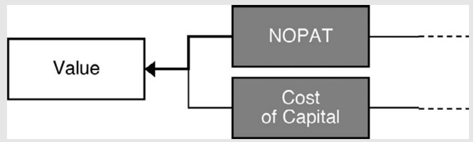
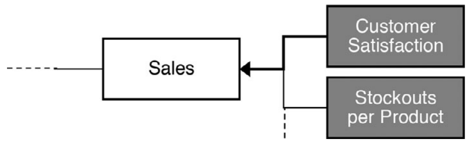
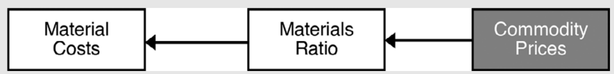
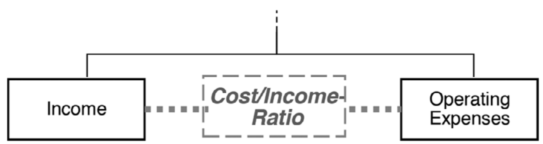
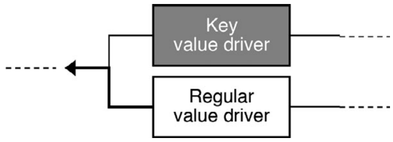
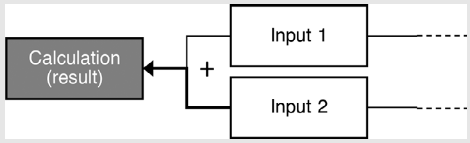
Indicator type				
Construct	***Description***	***Example***	***Occurrence (%)***	***Exemplary reference***
Key business indicator	Target indicator at the top of the VDT that represents a value relevant to the company and whose result is explained by the indicators below it.		100%	Pohlen & Coleman (2005); Hahn & Kuhn (2012)
Financial indicator	Monetary indicator derived from accounting, representing a financial (interim) result that is influenced by the operational performance of the company.		88%	Pohlen & Coleman (2005); Hahn & Kuhn (2012)
Value driver	Indicator that represents a factor of business performance that can be systematically influenced by the company and that has a significant impact on the higher-level financial indicators and, finally, the key business indicator.		91%	Taschner & Charifzadeh (2020)
External indicator	Factors from the external environment of a company that influence its performance but cannot be actively controlled by the company.		27%	Hartmann & Schönherr (2016)
Subsidiary results	Secondary results that do not play an immediate role in the logical hierarchy of the VDT, but are associated with it and are nevertheless of interest as indicators.		4%	Koller et al. (2020)

TABLE 4 VDT indicators—function.

Indicator function				
Construct	*Description*	*Example*	*Occurrence (%)*	*Exemplary reference*
Key value driver (regular indicator)	Value drivers that are of particular relevance (e.g., due to their influence on the Key Business Indicator) and on which a visual focus should therefore be placed in the presentation of the VDT.		33%	Koller et al. (2020)
Input/calculatio	Visual differentiation between the manageable input of a calculation and the derived (non-manageable) results.		8%	Kearney (2015)

the more structured mapping of the variety of company-specific indicators. For the target indicators, that is, those at the top of the VDT, the term "Key Business Indicator" was deliberately chosen. In the course of the study, it became clear that approximately 65% of the total 161 VDTs investigated deviate from the traditional understanding of value orientation (see Section 4) and implement alternative target indicators, such as simple profit ratios, costs, operational performance measures, or environmental indicators. Thus, this practice rather fits with a broader understanding of value from a stakeholder perspective (Harrison & Wicks, 2013). "Financial Indicators" typically represent monetary (lagging) results and are usually separated from the underlying (leading) VDs. Even though VDs can also reflect monetary values (e.g., machine set-up costs), a characteristic and differentiating feature of financial indicators is that they are primarily derived from the data source of financial accounting. In total, 88% of the 161 VDTs examined incorporated appropriate financial indicators (see the "occurrence" measure in Table 3). "Value drivers" (VDs) are characterized by the fact that they represent a factor of the performance dimension that can be influenced by the company and, in their consequence, affect the manifestation of financial results. In this context, it may also be useful to distinguish between operational and strategic VDs (see Section 2.2). The role of "External Indicators" (e.g., exchange rates or commodity prices) is emphasized more frequently in the context of VDTs (see, e.g., Valjanow et al., 2019). Especially in volatile environments, such external factors can have a significant impact on companies. Therefore, their modeling is important if, for example, a complete picture of possible developments is to be drawn for simulations (in the sense of what–if questions). The modeling of "Intermediate Results" is a means for representing relevant secondary or intermediate results that are not directly related to the logical hierarchy of the VDT, but are indirectly derived from it. In principle, it can also be useful to use a different coloring to distinguish the indicators (see, e.g., Koller et al., 2020).

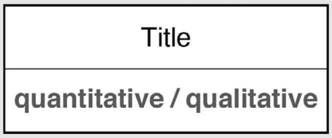
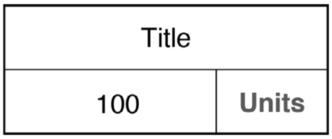
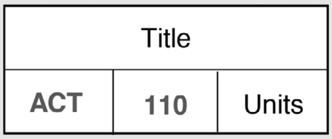
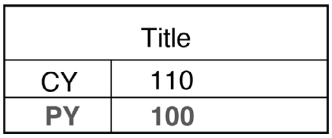
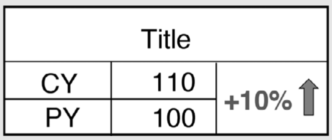
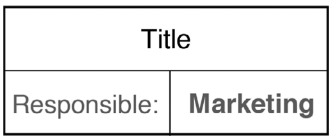
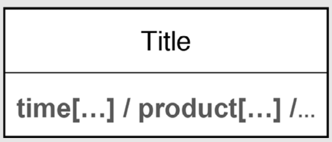
Function: In the syntactic presentation of indicators, visual means are often used to highlight certain indicators (see Table 4). This is to facilitate the focus on the essentials and, ultimately, the interpretation of the VDTs. Such means of highlighting are specifically used to draw attention to indicators with special functions, such as key VDs of particular importance, or to visually distinguish indicators that can be influenced (data input) from mere calculated results. Besides these examples, other visual highlights are also conceivable. However, such color schemes must be reasonably distinguished from any colors of the indicator types.

Content: Indicators can be illustrated with a wide variety of content (see Table 5); there is no uniform standard. With regard to the representation of the indicators, typical constructs were extracted during the ETDP, which can be variably combined. In addition to the simplest presentation of indicators with title and value, further contents are possible, such as the naming of further labels (e.g., metric units or data attributes), the indication of comparative values, or visualizations of developments and sensitivity information. The enhancement of such additional content can significantly substantiate and simplify the understanding of influences in the context of VDT interpretation (Akkiraju & Zhou, 2012).

5.2 | Connections

The characteristic feature of VDTs is that logical cause-effect chains are modeled along the inherent indicators

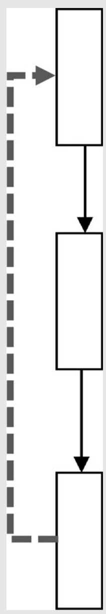
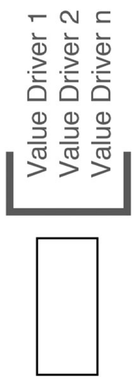
TABLE 5 VDT indicators—content.

Indicator content				
Construct	***Description***	***Example***	***Occurrence (%)***	***Exemplary Reference***
Title	Meaningful name of the indicator.		100%	Koller et al. (2020)
Value type	Supplementary specification of the type of a value (e.g., quantitative vs. qualitative, leading vs. lagging).		3%	Akkiraju & Zhou (2012)
Metric units	Units of a quantitative measurement (e.g., $, pieces, $/piece, %).		5%	Visser (2020)
Result	Type of result (e.g., actual, budget, forecast).		18%	Götze et al. (2019)
Comparative values	Statement of a second comparative value (e.g., current year vs. past year).		8%	Buckeridge et al. (2010)
Development	Visual or quantitative indication of a development.		10%	Horan et al. (2014); Hammer (2019)
Responsibility	Organizational unit or person accountable for the indicator.		3%	Kearney (2015)
Data attributes	Attributes of data management (e.g., table, time, product, category).		3%	Klauck et al. (2015)

(i.e., nodes) with corresponding connections (i.e., edges). Accordingly, the indicators of a VDT have to be connected visually to create a hierarchical system according to a tree structure. Such model constructs can be characterized by two categories: *links* and *operators*.

Links: The edges between indicators can be expressed in different ways (see Table 6). The most common form of expression is the direct connection of indicators (often with an arrow), which represents a direct analytical relationship, classically in the form of a mathematical path. Indirect connections are also possible, representing an indirect analytic connection that deviates from the typical hierarchical path of the tree structure (e.g., connections backward or across) and makes the tree structure more like a network (Anantharaman, 2018). In contrast, a weaker form of representation is the grouping of indicators in a list-like manner without the specific representation of analytical connections. However, the representation of specific mathematical paths and the direct explication of decision consequences—among the core purposes of VDTs—are only limited possible with such an informal form of modeling.

TABLE 6 VDT connections—links.

Connection: Links				
Construct	***Description***	***Example***	***Occurrence (%)***	***Exemplary reference***
Direct analytical link	Direct and immediate relationship between indicators in the VDT hierarchy that is analytically evident.		99%	Koller et al. (2020)
Indirect analytical link	Secondary and intermediate relationship between indicators in the VDT hierarchy that is analytically evident.		17%	Kratz & Kroflin (2016); Taschner (2022)
Logical allocation	Logical assignment of indicators to a higher-level indicator that cannot be captured analytically in an explicit form.		19%	Pohlen & Coleman (2005)

Operators: Operators are used to visualize the mathematical connections of indicators and thus to simplify the interpretation of cause-effect chains (see Table 7). Without the specification of operators, it is left to the users of the VDTs to determine the kind of mathematical relationships (i.e., addition, subtraction, multiplication, etc.) between data input ("child node") and result ("parent node") on their own. Advanced operators for more complex mathematical functions as well as operators for decision points are also conceivable. The modeling of mathematical functions has a comparatively low prevalence (occurrence of 4%). Decision point operators can be used to incorporate conditions for alternative paths of the VTD (in the sense of "if–then"). The neglection of operators, on the other hand, is rather suitable for purely logical, that is, non-mathematical relations, which, however, deprives VDTs of their analytical strength (i.e., the explication of calculative interdependencies).

5.3 | Structure

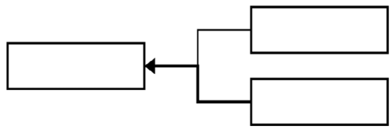
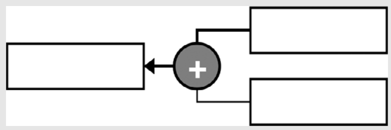
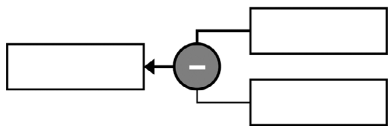
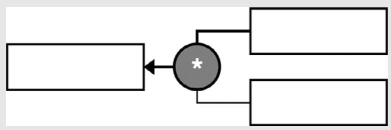
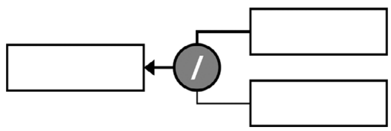
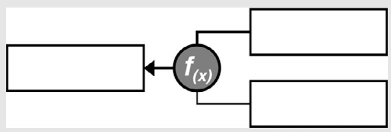
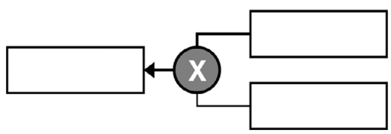
VDTs can quickly become overloaded and deprived of their intended purpose of complexity reduction the more indicators and connections are modeled (Valjanow et al., 2019; Wall & Greiling, 2011). Nevertheless, to ensure clarity in interpretation, modeling of structure-creating elements is useful (Akkiraju & Zhou, 2012). The previous practice of VDT modeling suggests that corresponding constructs can be used to create structure: *levels*, *clusters*, and *decompositions*.

Levels: Levels stand for a content-related structuring of the tree branches and can significantly increase the clarity, for example, by ordering the branches according to indicator types (e.g., by separating the branches with financial indicators, VDs, or external indicators). This way, the role but also the possible influence on the indicators of the VDT can be made clearer (see Table 8). Further levels, for example, for the subdivision of indicators according to temporal management horizons, are also feasible.

Clusters: Clusters (see Table 9) represent a grouping of indicators according to various aspects, such as the respective association to the underlying business model or the association to operational functions. The advantages of clusters are that they allow the user's attention to be focused on specific interrelationships beyond the presentation of individual indicators.

Decomposition: VDTs become more complex as the number of branches and modeled indicators increases. Although there is no clearly definable measure, Pulay and Simon (2020) argue that already the fourth branching (hierarchy level) in VDT can lead to an overload. This is a known and significant problem of VDT implementa-

TABLE 7 VDT connections—operators.

Connection				
Construct	***Description***	***Example***	***Occurrence (%)***	***Exemplary reference***
Logical (L)	Logical relationship between indicators, without further indication of its calculation.		82%	Koller et al. (2020); Werner (2016)
Addition (+)	Addition of indicators (child nodes) to a result (parent node) following in the VDT hierarchy.		34%	Strack & Villis (2002); Hammer (2019)
Subtraction (-)	Subtraction of indicators (child nodes) to a result (parent node) following in the VDT hierarchy.		41%	Strack & Villis (2002); Hammer (2019)
Multiplication (x)	Multiplication of indicators (child nodes) to a result (parent node) following in the VDT hierarchy.		34%	Strack & Villis (2002); Hammer (2019)
Division (/)	Division of indicators (child nodes) to a result (parent node) following in the VDT hierarchy.		14%	Hammer (2019)
Function (fx)	Mathematical function (e.g., calculation of averages or the application of a statistical regression function) that processes the input of indicators (child nodes) to a result (parent node) following in the VDT hierarchy.		4%	Werner (2016);
Gateway (X)	Decision point in a VDT hierarchy that can change the path of the VDT (e.g., either path A or path B) under certain conditions (e.g., the value of a previous indicator).		1%	Rese & Herter (2007)

tion (Koller et al., 2020; Wall & Greiling, 2011; Weber et al., 2017), because if the level of detail and the degree of influence of the modeled indicators are incorrectly assessed, the effective operationalization of VDTs will be hindered. To avoid this, decomposition solutions are suitable (see Table 10), such as splitting a VDT into several subtrees or the targeted pruning of the tree structure.

Finally, to demonstrate and further evaluate the VDT Model Classification according to the ETDP (Kundisch et al., 2021), an exemplary VDT was modeled with the introduced constructs (see Figure 7). According to Kundisch et al. (2021, p. 434), the goal of such an application-based evaluation is to "evaluate [...] whether the present version of a taxonomy fulfills the sufficient condition to be an applicable taxonomy." For this purpose, a VDT from the literature (an example loosely adapted from Brandenburg, 2013; Hahn & Kuhn, 2012) was re-modeled and revised. The goal of the evaluation was to test whether (1) the constructs of the classification could be used without deficits or redundancies (see Wand & Weber, 1993). In the context of this initial test conducted in an artificial scenario, these criteria could be met since neither deficits

TABLE 8 VDT structure—levels.

Structure: Level				
Construct	***Description***	***Example***	***Occurrence (%)***	***Exemplary reference***
Indicator type	Structure of the VDT hierarchy by type of modeled indicators.	Business Value Driver / Financial Indicators / Value Driver	34%	Hahn & Kuhn (2012); Cao et al. (2006)
Branch level	Structure of the VDT according to the number of hierarchical levels.	Value Driver Level #1 / Value Driver Level #2 / Value Driver Level #3	4%	Görner et al. (2020)
Time horizon	Structure of the VDT hierarchy according to management timeframes.	Short-Term Value Driver / Medium-Term Value Driver / Long-Term Value Driver	1%	Koller et al. (2020); Hahn & Kuhn (2012)

(i.e., constructs that may be required are not present) nor redundancies (i.e., two constructs serve the same modeling purpose) were found. Moreover, based on the impressions of the involved reviewers (two researchers and one practitioner), it can be said that the constructs of the classification have promising usefulness as they contribute to clarity and easier interpretation of the demonstrated VDT. Further perspectives on the corresponding evaluation are outlined in Section 6.

6 | RESEARCH AGENDA

Based on the findings collected during the research process, a research agenda will be outlined (see Table 11), which in general addresses the role and future potentials of VDTs and, in particular, describes the next steps toward a profound notation for the modeling of VDTs.

A. *General Understanding of VDTs in Theory and Practice*: In general, the review of the VDT literature revealed a lack of sound scientific research. This is surprising, because although the term "value driver" is widely used and the importance of establishing causal models of these very drivers has been postulated for many years (see Ittner & Larcker, 2003), the scientific contributions that guide researchers and practitioners in doing so are very limited (Wobst et al., 2023). For this reason, the first stream of this research agenda addresses the outline of the basic research territory. (A.1) The review of the VDT literature showed that a highly heterogeneous understanding of VDTs has developed over the decades (see Section 4). It is particularly noticeable that the term "value" has shifted from a traditional understanding in the sense of shareholder value (see Rappaport, 1986, 1998) to a broader concept of value in the sense of stakeholder value (see Harrison & Wicks, 2013; Wall & Greiling, 2011). This is clearly illustrated by the sheer breadth of implemented key target indicators, which reflect not only the traditional value-based metrics (such as Economic Value Added®) but increasingly also general performance metrics (such as productivity figures). Another option is the modeling of environmental, social, and governance (ESG) indicators (see, e.g., Lisi, 2015; Schramade, 2016). Following on from this, a further, largely unsolved problem is to confirm the actual suitability and statistical significance of potentially relevant VDs. Practical studies regularly mention the challenge of identifying significant VD (see, e.g., Federmann et al., 2020). While there are reports of best practices in this regard (e.g., by using of the System Dynamics methodology; see Federmann et al., 2020), the problem of VD identification has not

TABLE 9 VDT structure—clusters.

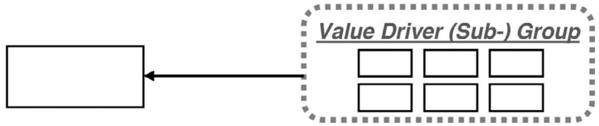
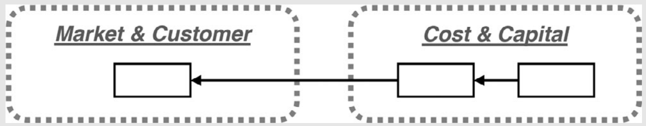
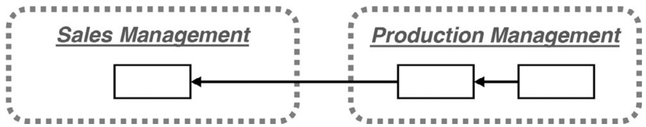
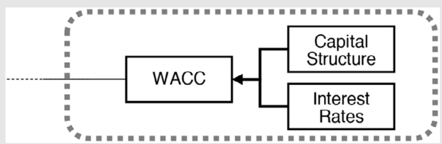
Structure: Cluster				
Construct	***Description***	***Example***	***Occurrence (%)***	***Exemplary reference***
Value driver (sub-) group	Grouping of value drivers into a cluster that has a logical, but not individually specified, influence on an assigned indicator.		24%	Pohlen & Coleman (2005)
Business Model	Grouping of indicators based on their association with specific areas of the business model.		13%	Boeckmann (2019)
Functions	Grouping of indicators based on their association with specific functional or organizational areas of the company.		4%	Hofmann & Locker (2009); Woo & Song (2014)
Calculations	Grouping of indicators on the basis of their association with a calculation to be specifically illustrated in the VDT.		6%	Haraldsson & Moldén (2013)

TABLE 10 VDT structure—decomposition.

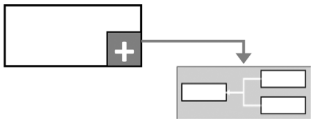
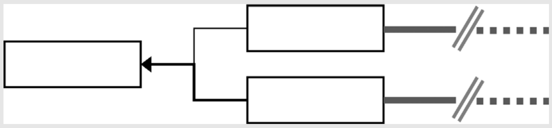
Structure: Decomposition				
Construct	***Description***	***Example***	***Occurrence (%)***	***Exemplary reference***
Sub-tree	Decomposition of a VDT by representing more extensive connections of an indicator in a separate sub-VDT.		6%	Seufert (2019)
Tree cut	Pruning of a VDT by neglecting more extensive connections and merely referencing them.		16%	Ante et al. (2018)

TABLE 11 Research agenda.

Topic	**Research Question**		**Description**
A.	General Understanding of VDTs in Theory and Practice		
	A.1	*How can VDTs be characterized in theory?*	Elaborating on the current vague understanding of VDTs and their characteristics.
	A.2	*For what and how are VDTs used in practice?*	Learning from the practical use of VDTs, identification of deficits, and formulation of recommendations for practice.
	A.3	*What are the future application potentials of VDTs?*	Outline, demonstrate, and evaluate advanced, e.g., digitized, use cases.
B.	Evaluation and Revision of the VDT Model Classification		
	B.1	*Are the requirements for a sound and complete classification met?*	Evaluation of the proposed classification using common quality criteria (construct overload, redundancy, excess, deficit).
	B.2	*How can the classification be revised and further developed?*	Revision of the proposed classification (deletion, merging, shifting, renaming, or expansion of constructs).
C.	Design and Performance Evaluation of a VDT Modeling Notation		
	C.1	*What does a complete VDT Modeling Notation look like?*	Design of a notation set with a complete set of rules, implementation guidelines, and examples.
	C.2	*Does the VDT Modeling Notation meet the relevant performance requirements?*	Evaluate the proposed notation against common quality criteria (e.g., fidelity, efficiency, reliability, supportability, space economy).

yet been systematically studied in research. In fact, an undefined aspect in the context of VDTs is the question of what a "value driver" actually means. This also involves addressing central challenges in the use of VDTs, which is the establishment of robust mathematical cause-and-effect relationships between indicators or accounting for temporal shifts when measuring such relationships (Abernethy et al., 2005; Mastilak et al., 2012). Especially the latter, the mapping of causal time lags between the steering of the VDs and their realized effects, is a known, but yet still unsolved problem (Abernethy et al., 2005). Although the relevance of such causal models has long been known, it is surprising that only 4% of the VDTs examined establish advanced mathematical functions. In conclusion, future research efforts should therefore deal with creating a more sufficient conceptual understanding of the VDT methodology. (A.2) Another interesting research perspective is to investigate the practical use of VDTs. This could include empirical investigation of the prevalence of VDTs in practice, as well as their specific areas of use (e.g., through survey research). Building on this, the influences of the VDT use on decision-making in the VBM context could be studied (e.g., through case study research, expert interviews, or laboratory experiments). This would allow an assessment of the general benefits and limitations of the VDT use for VBM purposes and would contribute to the research on VBM sophistication (see Burkert & Lueg, 2013; Nowotny et al., 2022). In this way, potential shortcomings in the VDT application can be identified and targeted recommendations made to practitioners. (A.3) One more research avenue opens up for outlining future application potentials. Due to their ability to systematically map the network of cause-effect relationships in a company's business model, VDTs are seen as a conceptual platform for the implementation of many digitized use cases (Brosig et al., 2019), such as computer-aided scenario simulations (Klauck, 2015), predictive forecasting (Valjanow et al., 2019), or AI (Gupta et al., 2022; Kiron & Schrage, 2019). The development, demonstration, and evaluation of these use cases (e.g., in case studies) could make interesting contributions to the further digitalization of corporate accounting and finance. Powerful control systems can be created in this way, as outlined by Fähndrich (2023, p. 29): "In combination with statistical analysis methods and machine learning analytics, [management control] is able to put these value drivers into a logical relationship and transfer them into a evaluable model [and …] to determine the strength and duration of value drivers." Wobst et al. (2023) also emphasize the considerable potential that arises from the great availability of data in an increasingly digitalized environment to not only develop but also evaluate VDTs. In addition, from an information systems perspective, research on the design and usability of VDT-supporting software solutions is equally interesting, of which there are now several, such as SAP Analytics Cloud (see Gole & Shiralkar, 2020).

B. *Evaluation and Revision of the VDT Model Classification*: The theory of ontological expressiveness provides guidance for testing the quality of conceptual modeling grammars (see Burton-Jones et al., 2009). (B.1) The evaluation of the VDT Model Classification and its constructs offers research potential in this respect (e.g., by testing them in illustrative scenarios with real-world objects). For this purpose, Wand and Weber (1993) propose the testing of four typical defects: *construct overload* (the semantic problem that the classification contains constructs that have more than one specific meaning); *construct redundancy* (the syntactic problem that the classification provides multiple types of syntax [symbols] to represent one type of semantic construct); *construct excess* (the semantic problem that the classification contains constructs that are meaningless for the modeling purpose); *construct deficit* (the semantic problem that the classification does not contain all constructs necessary for the modeling purpose). However, the semantic constructs as such require not only further examination but also their best possible visualization, which is essential for the success of visual notations (D. Moody, 2009). The syntactic elements presented in this paper are so far only exemplary in nature. (B.2) Therefore, further evaluation can form the basis for the revision of the initial classification (i.e., deletion, merging, relocation, renaming, or extension of constructs, as well as further development of their visualization). In this context, attention can also be paid to the current prevalence (the % of occurrence) of the individual constructs. For example, some constructs, e.g., operators with mathematical functions (4%) or the indication of responsibility in the indicator content (3%), are less frequently used in VDT modeling. However, this does not mean that their incorporation cannot make a positive contribution to the VDT model and its interpretability. Corresponding evaluations may provide an interesting starting point for future research.

C. *Design and Performance Evaluation of a VDT Modeling Notation*: A complete modeling language goes beyond the mere classification of model constructs and can be understood as a notation set (i.e., a set of symbols with assigned meanings) that is based on a complete set of rules (i.e., a set of rules for how to combine these symbols) to provide comprehensive guidance for the representation of knowledge (Krogstie, 2019). (C.1) For the further design of a VDT Modeling Notation, a complete and well-founded set of rules of its semantic constructs, their visual representation, and the systematic combination in a structured model has to be formulated (Harel & Rumpe, 2004). A major problem of VDT modeling could also be addressed in this course, namely the decision of when an indicator is actually a VD that should really be modeled (Wall & Greiling, 2011). In this context, validation of "significant influence" is often challenging (Valjanow et al., 2019). Guidance for objective validation (ideally tool-based) of a VD and its impact on business performance is urgently needed (see also Ashton, 2007). This is a prerequisite for VDTs to serve the purposes of digitalization (Fähndrich, 2023; Valjanow et al., 2019). Logical (subjective) connections between indicators (i.e., those substantiated by qualitative arguments) cannot serve digitalized use cases that require a consistent mathematical system (e.g., in predictive forecasting). (C.2) According to Burton-Jones et al. (2009), a modeling notation should fulfill certain performance requirements for effectiveness (fidelity) and efficiency principles, such as *representational fidelity* (how faithfully does a modeled VDT represent a modeler's perception?), *representational efficiency* (what resources, such as time, are used to model a VDT?), *interpretational fidelity* (how faithfully does the interpretation of the VDT represent its real semantics?), and *interpretational efficiency* (what resources, such as time, are used to interpret the VDT?). Further evaluation criteria could be, for example, those formulated by Paige et al. (2000): *reliability* (does the notation reliably promote modeled VDTs?), *supportability* (is the notation supportable by tools?), or *space economy* (are the modeled VDTs concise?). All of these are performance measures of a systematic VDT modeling language that need to be evaluated from the perspective of the designers (e.g., representational efficiency) or from the perspective of the users who need to interpret the VDTs (e.g., interpretational efficiency). Appropriate evaluations form a final research path. D. L. Moody (2005) describes possible methodologies, such as laboratory experiments, case studies, or action research, among others.

7 | CONCLUSIONS

7.1 | Contributions

As a result of this study, a VDT Model Classification is proposed whose contribution can be justified by the DSR paradigm (Hevner et al., 2004; Peffers et al., 2007). DSR aims to develop and evaluate innovative and applicable artifacts that contribute to solving a relevant problem of practice (Hevner et al., 2004). The VDT Model Classification is to be understood as such an artifact in the form of a language concept. A classification in this form fulfills the "need to standardize terminology and concepts for information sharing across organizations and applications" (Parsons & Wand, 2008, p. 841). In this way, it provides a viable contribution to the further development of VDT modeling competencies in theory and practice by summarizing and structuring the usual constructs of a VDT model as well as their possible visualization in a conceptual framework. In this respect, the RQ regarding the semantics and syntax of VDT modeling was answered. It is well known that this kind of transparency improves the understanding, the communication and, ultimately, the development of knowledge in a business context that is appropriately depicted (Indulska et al., 2009). Another contribution implicit to the research process is that the research territory on the concept of VDTs has been outlined. Based on an extensive review of the VDT literature, a research agenda was formulated that highlights, on the one hand, the relevant questions that should be answered for a better understanding of VDTs as a methodology. On the other hand, it identifies research paths for the further development of VDT modeling competencies.

7.2 | Implications for research and practice

Implications for research arise primarily from pursuing the outlined research agenda. Basically, two possible research streams are outlined here. One is the further study of VDTs in general, that is, their conceptual understanding as well as their practical applications and contribution for VBM purposes. It is striking that, although VDTs are widely used in practice, no research has been done on their fundamental conception. This lack of theoretical guidance is an evident research gap that has been specifically uncovered for the first time in this study. On the other hand, with respect to the proposed VDT Model Classification, the research path of its further development, as well as the design of a VDT Modeling Notation based on it, can be followed. However, in a broader sense, the classification proposed here can also serve as the conceptual basis for further research efforts on VDT modeling in theory and practice. For example, the empirical study of real-life VDTs can be mentioned, for which the conceptualized dimensions, categories, and constructs can form the investigation framework.

Implications for the practice of VDT modeling arise from the fact that, based on the proposed conceptual classification, more transparency is already provided about the constructs and representation of VDT models, which can already provide preliminary "decision guidance" for modelers. It is surprising that there is still nothing comparable in this respect. However, through the research on other conceptual modeling languages, it is known that such systematic guidance can not only contribute to the standardization and consequently easier interpretation of systematically designed models, but also to the enrichment in terms of their information value (Indulska et al., 2009). Furthermore, by analyzing the extensive VDT collection, seven recommendations for the practice of VDT modeling can already be made at this point.

1. *Information content of VDT indicators*: The first recommendation is to increase the information content of the indicators presented in VDTs. In addition to the title and the simple result value of an indicator, other content such as comparative values, developments,

data attributes or responsibilities (see Table 3) can significantly broaden the interpretation possibilities of indicators and, ultimately, of VDTs. The study shows that comparatively little use is made of such content.

2. *Structure of VDTs*: The second recommendation is to include structuring elements. It is well known that VDTs are deprived of their informational value if they become too extensive and complex (Valjanow et al., 2019; Wall & Greiling, 2011). Levels are suitable to give order to VDTs with many branches; clusters are applicable to group many indicators thematically. Especially in more complex VDTs, structural elements can help to clarify logical relationships of sub-areas (e.g., different responsibilities or the bundling of intermediate results) and ultimately speed up the interpretation of VDTs.
3. *Decomposition of VDTs*: If the structuring elements do not noticeably increase clarity, a third recommendation is to incorporate appropriate decompositions for dividing or pruning VDTs. It is argued that already a fourth branching (hierarchy level) in VDTs can lead to an information overload (Pulay & Simon, 2020). This is a known and significant problem of VDT implementation. Therefore, the decomposition of VDTs into several more easily interpretable parts can be an effective solution here.
4. *Operators of VDTs*: A fourth recommendation to increase interpretability is the use of mathematical operators. Surprisingly, these are only used by a smaller proportion of the VDTs studied, although they considerably simplify understanding the calculation paths and prevent interpretation errors. Therefore, the integration of simple mathematical relationships (i.e., addition, subtraction, multiplication, etc.) between data input ("child node") and result ("parent node") could significantly improve the interpretation of VDTs.
5. *Mathematical linking of VDT indicators*: The fifth recommendation is to pay more attention to the direct linking of indicators. About 20% of the VDTs studied modeled indicators in part only with logical allocations in the form of list-like groupings (see Table 6). To unlock the full potential of VDTs as a platform for advanced analytical use cases, cause-effect relationships should be mapped as completely as possible, using direct/indirect analytical links and appropriate operators. Only then does a VDT become a complete system in the form of a mathematically consistent "value index" (Ashton, 2007, p. 4). For this purpose, Wobst et al. (2023) emphasize the analytical possibilities offered by the ever-increasing availability of data.
6. *Informational context of VTD indicators*: The sixth recommendation addresses the presentation of indicators as such. In the course of this study, the common statement of the literature (Akkiraju & Zhou, 2012), that indicators should be enriched with more informational context (e.g., comparative values, trend developments, or background information), can also be confirmed. For example, Nowotny et al. (2022) emphasize the importance of integrating an organizational perspective in VD interpretation. In this way, interpretations and decisions (e.g., in relation to responsibilities) can be more informed in the business model context.
7. *Implementation of digitalization use cases*: The seventh and final recommendation is to use the potential of the VDTs to implement advanced solutions in corporate accounting and finance. Advanced methods, such as predictive forecasting or computer-aided business simulation and optimization, require soundly modeled and, above all, calculable representation of a business model. However, once such a meaningful and calculable indicator system is established, computer-aided business forecasting, simulation and optimization can be properly performed.

7.3 | Limitations

The development of the proposed classification is not without potential limitations inherent in the research design used. First, instead of empirically surveying VDT modeling practices in a real-life context (i.e., in companies), a literature review of published VDT models was relied upon. Consequently, the results generated from this review can only provide insights into the common design of VDTs than into the actual use and respective benefits of these VDTs. Furthermore, the literature review conducted was comprehensive, but certainly not complete in terms of capturing the full practice of VDT modeling. Second, the application of the ETDP (Kundisch et al., 2021) requires human judgment at several points (especially in the selection of meta-characteristics and in the conceptualization of categories and constructs). Of course, conflicting cases were also decided by the judgment of the researchers in this process. In order to ensure the quality of the generated classification in the first step, it was tested against objective and subjective evaluation criteria (latter examination also with the participation of a panel of experts), and its use was practically illustrated. Nevertheless, it can be assumed that the initially proposed classification should be revised and extended in further evaluation rounds. The proposed research agenda outlines the path for this.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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