Fluxing between conceptual models - An experiment from e^3*value* to BPMN

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Abstract

In the context of modern interconnected organizations seeking coordination and trustable solutions in enterprise systems, conceptual modeling plays a pivotal role. This paper explores the application of conceptual modeling to enhance the integration of principles and practices required for successful enterprise system development in the domain of Digital Business Ecosystems and Blockchain technology. Specifically, it focuses on addressing challenges related to supporting the redesign of a Digital Business Ecosystem that has blockchain or any other type of Digital Platforms. Conceptual modeling provides a multifaceted perspective for dissecting and understanding digital business ecosystems, enabling the exploration of diverse strategies during inception and management phases. In the face of substantial shifts within the blockchain-based business ecosystem, this study emphasizes the need for reevaluating two key conceptual modeling angles: (1) assessing business value through an e^3*value* model, and (2) examining business processes using a BPMN model. To streamline the elicitation process, we used a case study in which we use an existing business value model to derive a process model effectively. The primary objective of this research is to validate a set of guidelines for translating an e^3*value* model into a BPMN process model. To achieve this, a controlled experiment involving students well-versed in both conceptual modeling languages will be conducted. The quality of models generated using the proposed guidelines will be assessed by domain experts, focusing on factors such as validity and comprehensiveness. Additionally, an analysis of the experimental outcomes will be undertaken to identify limitations and inform future research endeavors.

Keywords

Digital Business Ecosystems, e^3*value* model, BPMN

1. Introduction

Establishing an ICT-enabled ecosystem necessitates a variety of requirement-oriented perspectives, to which different conceptual modeling languages can help in with the task [1]. Remaining viable in the corporate landscape necessitates companies to swiftly acclimate to the escalating pace of dynamic business conditions. To align with these shifts, business models need to adeptly mirror these transformations, business processes must be meticulously fashioned to facilitate seamless value exchanges, and information technology applications must seamlessly realign with the evolving objectives of the company [2]. Among these viewpoints, the busi-

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ness model perspective and the business process perspective are crucial, each encompassing distinct considerations. In our approach, we employ the *e*^{3}*value* language [3] for articulating the business model perspective and utilize the BPMN [4] notation for the business process perspective. While there are areas of convergence between these two regarding their ontology, substantial discrepancies also exist. For instance, *e*^{3}*value* introduces the concepts of economic reciprocity and commercial bundling from the supplier and customer standpoint, which are absent in BPMN. Conversely, BPMN captures the notion of sequencing activities in terms of time, while *e*^{3}*value* focuses solely on causal dependencies.

Given these overlaps and differences, the possibility arises to derive partial models from one another. Although digital business ecosystem development often commences with the design of an *e*^{3}*value* model, numerous projects entail refining an existing operational ecosystem. Such endeavors might involve optimizing the system or capitalizing on new opportunities spurred by technological advancements. Our approach assumes that the business model is formulated using *e*^{3}*value*. Nevertheless, our method can potentially be applied in tandem with alternative business process notations, lacking a principled argument against such an integration.

The core inquiry lies in whether the established business model, as articulated in the *e*^{3}*value* language, can be used to deduce a corresponding process model, such as in a BPMN process model. Specifically, we aim to leverage the insights embedded in business models to craft a corresponding process model that encapsulates business value considerations. This alignment is feasible to a certain extent due to conceptual overlaps in their ontology. Nonetheless, our practical experience reveals that automating the conversion of BPMN models into *e*^{3}*value* models is challenging due to significant semantic distinctions imbued in their ontology [5]. In this context, employing guidelines can expedite the process of deriving the latter from the former, capitalizing on the elicited and modeled requirements in the *e*^{3}*value* framework.

Our research endeavors investigated the quality of models generated by these guidelines, particularly in terms of their efficacy in aiding modelers to extract process models from pre-existing business models. The ensuing research questions are outlined as follows:

RQ 1. Is it possible to derive a valid and reliable BPMN model from an *e*^{3}*value* model using a set of guidelines?

RQ 2. Are there other factors affecting the quality of the model derived by the guidelines?

In pursue of these answer we performed a controlled experiment. Subjects were briefed to derive a BPMN model starting from an *e*^{3}*value* model with the help of a set of guidelines. The domain experts measured the completeness and validity of the subject's derived models. Our research not only provides further evidence on the ontological overlap between these two conceptual modelling languages, but also creates a tool to facilitate digital business ecosystems analysis, management and (re)design.

The paper is distributed as it follows. In Sec. 2, we inform the literature gap and discuss the related work. In Sec. 3, we present the setup for the controlled experiment. We conclude and set plans for future research in Sec. 4.

2. Background and related work

While we assume the reader's familiarity with the widely recognized BPMN language in conceptual modeling, in the interest of self-contained content, we will provide a concise introduction to the *e*^{3}*value* method. For a more comprehensive elucidation, please refer to [3].

2.1. *e*^{3}*value* modeling

The *e*^{3}*value* language ([3]) is an approach in the field of business modeling. Other approaches include the Resource Event Agent (REA) ([6]) ontology and value stream mapping ([7]). E^3 value is particularly powerful in representing and analyzing the ecosystem or, as it is called in *e*^{3}*value*, the networked value constellation ([8]) of enterprises that collectively satisfy one or more needs of an end-user.

We will briefly elucidate the pertinent *e*^{3}*value* constructs, utilizing an illustrative educational example (depicted in Fig. 1) to expound on these concepts within the scope of this paper. Noteworthy *actors*, like Amazon.com, hold both financial responsibility and accountability for gains and losses, frequently constituting distinct legal entities. In numerous instances, it proves beneficial to discuss multiple actors of similar nature, delineating *market segments* characterized by analogous economic value assignment. Instances include individuals who wish to read a book (referred to as readers) and publishers. These actors and market segments engage in *value transfers* amongst themselves, wherein the subject of such exchanges is the *value object* (e.g., a book, transportation service, currency) that carries economic significance for at least one of the participating actors or market segments. These value objects are exchanged through designated *value ports*, categorized under overarching *value interfaces*. These interfaces signify economic reciprocity, thus encompassing at least one inbound value port and one outbound value port.

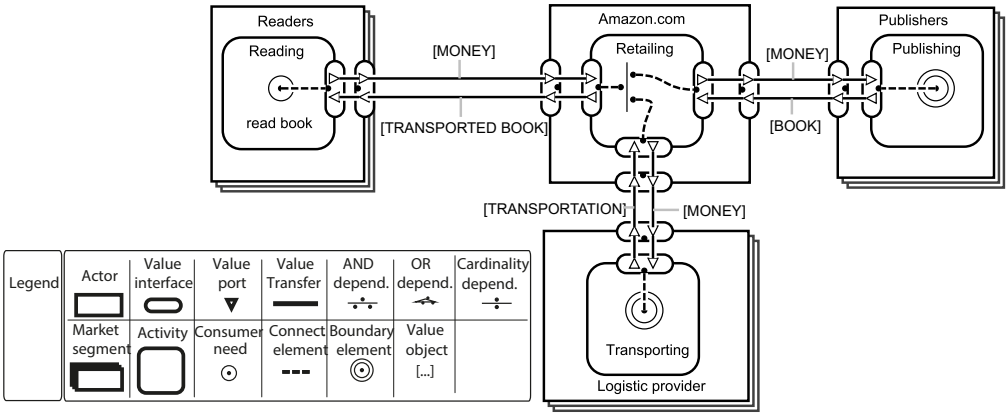


Figure 1: An educational *e*^{3} value model

Actors and market segments conduct value-related activities with the aim of generating revenue (in the case of companies) or augmenting economic utility (in the context of end-users). The requisites of customers (such as the desire to read a book) signify a state of perceived deprivation experienced by an actor. This void is satisfied through one or more value objects,

which are symbolized by *dependency connection elements*. At the conclusion of the dependency chain, one or more *boundary elements* are introduced, signifying that further value exchanges are no longer within consideration. This should not be misconstrued as an absence of such interactions (for instance, publishers engaging in transfers with writers); rather, it indicates that these interactions lie outside the limits of the model. Consequently, boundary elements are the demarcations of the model.

2.2. Related work

A number of researchers have paid attention to the derivation of process models from other conceptual models and vice versa [9, 10, 11, 12]. Also, work has been done to relate business model e^3*value* to the Resource Event Agent (REA) framework ([6, 13]), which was also the basis for a mapping to UN/CEFACT Methodology (UMM) models [14, 15]. In previous work [16, 17], we have proposed a set of guidelines to derive an e^3*value* model by using a BPMN model as input, in this paper we aim to do the exact opposite. The point of departure is the fundamental ontological difference between value and process models, e.g. explored in [18]. Follow-up research investigated this in more detail, e.g. by [19], where formal consistency rules are defined between value and process models.

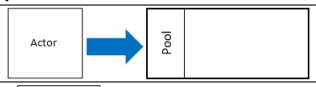
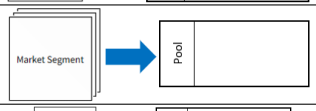
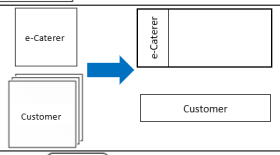
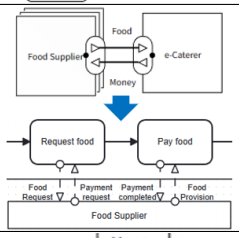
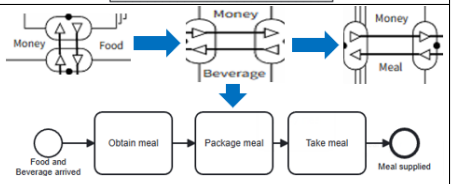
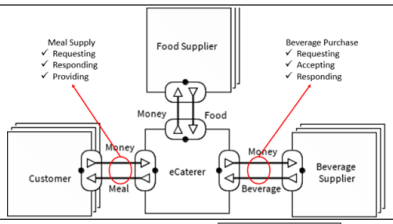
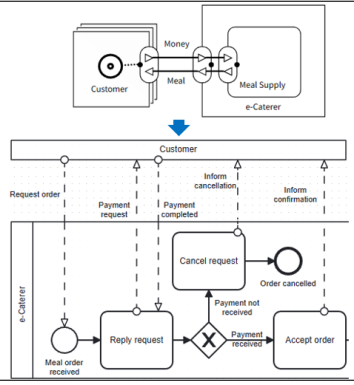
We contend that the inherent semantic disparities between the models render an automated translation unfeasible (refer to [18]) for notable distinctions). In light of this, we propose an alternative approach rooted in design principles. For instance, in [20], a method employing intermediate models was introduced to derive a BPMN model from an e^3*value* model. Our solution omits the use of meta-models, focusing on establishing a correlation between the ontological concepts of e^3*value* and the Business Process Specification Schema [21].

In terms of empirical validation for such a derivation methodology, analogous endeavors have been undertaken in comparing disparate conceptual models. Examples include the comparison between user stories and use cases ([22, 23]), BPMN against textual use cases ([24]), and various modes like textual, semi-structured, and diagrammatic ([25]). Given that our modeling tasks are executed by students and evaluated by domain experts, we factor in System Quality (SQ). This aspect accounts for the desired attributes of a system/tool (i.e., our guidelines), which yield the information output (i.e., the derived BPMN model). This is inherently tied to the perceived ease of understanding and perceived usefulness of the tool for the modelers (i.e., participants) [26].

3. The controlled experiment

We conducted a controlled experiment (adapted from [26]) in which we analyzed the quality of a conceptual model – Business Process Notation v.2.0 (BPMN) – derived from another conceptual model – e^3*value* modeling – using guidelines. The guidelines are summarized in Table 1. The model derived from the guidelines was evaluated by domain experts. For that we used user's satisfaction, as in our opinion, a general evaluation of the quality of a conceptual model can be measured in terms of how satisfied users (i.e domain experts) are with the model with respect to its purpose [27]. Consequently, this resulted in the identification of four interconnected variables that evaluate the guidelines and the derived model. Perceived Semantic Quality (PSQ), Perceived Ease of Understanding (PEU), Perceived Usefulness (PU), and User Satisfaction (US).

Table 1
Guidelines – from *e*^{3}*value* to BPMN model

ID	Guideline	Example
G1	Every Actor in the e3 value model will correspond to a Pool in the BPMN model.	
G2	Every Market segment in the e3 value model will correspond to a Pool in the BPMN model.	
G3	Select a starting point for your BPMN model.	
G4	Value Activities in the e3 value model will be represented as an activity/sub-process in the BPMN model.	
G5	Identify the chronological order of value transfers in the e3 value model.	
G6	Identify the physical flow of the value objects in the e3 value model and translate to the appropriate sequence of activities required to fulfill it.	
G7	Value interfaces in the e3 value model may show hidden activities/sub-processes for the BPMN model.	
G8	Sequence is required for tasks/sub-processes and different actors in BPMN, we then introduce sequence, control and message flow links by analyzing informational, fulfillment and deontic conditions in the e3 value model.	

3.1. Experiment design

We indicate that in our experiment, PSQ and PEU exhibit no intrinsic correlation. Models perceived as comprehensible are likely to engender a higher level of contentment regarding their ability to effectively convey the user's perspective of the domain. This notion aligns with earlier research suggesting that heightened perceived semantic quality may lead to an increased sense of user satisfaction [28]. In both [29] and [26], the PU construct pertains to attitudes that take shape based on past usage perceptions. Therefore, if users perceive the derived models to be practical for articulating and conveying their domain-related viewpoints and requirements, a corresponding contentment with the guidelines is probable. Our experimental framework has been adapted from [26].

Therefore, we underpin the basis for our causal relationships, which hypothesize:

- H_1: *If there is an increase in PEU of the guidelines/derived model it will cause increase in US.*
- H_2: *If there is an increase in PSQ of the guidelines/derived model it will cause increase in US.*
- H_3: *If there is an increase in PU of the guidelines/derived model it will cause increase in US.*

If a user encounters two conceptual modeling languages that are believed to possess equivalent informational content [30], it is plausible that the more comprehensible notation will be deemed more valuable. Therefore, our hypothesis posits that PEU exerts an impact on PU.

Users also form perceptions of their semantic quality. It stands to reason that these perceptions might also sway the user's assessment of usefulness. When users perceive the derived model to be flawed or incorrect in relation to the problem domain, their evaluation of the guidelines' usability is likely to be less favorable. Thus, an additional hypothesis suggests an influence of PSQ on PU.

As a result, we articulate the final two relationships:

- H_4: *If there is an increase in PSQ of the guidelines/derived model it will cause an increase in PU.*
- H_5: *If there is an increase in PEU of the guidelines/derived model it will cause an increase in PU.*

3.1.1. Subjects.

We involved PhD students at University of Sao Paulo (USP), and also at Vrije Universiteit Amsterdam (VU). The students-subjects are familiar with e^3*value* and BPMN. They also practiced e^3*value* and BPMN through homework assignments, and had to prove that they understand the notations well.

The participants in the experiments may not precisely mirror the intended user demographic of the guidelines, which primarily caters to professionals like consultants and software engineers. Nevertheless, we contend that employing students for these experiments is justifiable for several reasons. Firstly, students possess significant familiarity with both BPMN and e^3*value* due to substantial practice. In contrast, training consultants to a similar degree would demand a substantial investment of their time. Secondly, using students facilitates the inclusion of a substantial number of test subjects, which could prove challenging to achieve with consultants.

Lastly, the participation of two universities from distinct countries (Brazil and the Netherlands) lends an element of heterogeneity to the experiment's outcomes, enhancing the diversity of results.

3.1.2. Experiment Materials.

We designed the experiment in which the students would draft the BPMN model using the e^3*value* model as input and the guidelines as a support tool. For that purpose, we designed a form that contain four parts: (1) a pre-test questionnaire that checks the subjects' background and knowledge (on BPMN and e^3*value*); (2) the first task, in which subjects receive the requirements of the Intellectual Property Rights (IPR) ecosystem, specified in e^3*value*, and will be asked to derive the BPMN model with the help of the guidelines. In order to accomplish this, we have worked with persons affiliated with the IPR society NL (SENA; exploitation on neighboring rights); (3) a post-test with questions about the subjects' perception of the guidelines and the experiment overall; (4) we will use a measurement instrument to evaluate the guidelines and the derived models. The experiment will be performed via online meeting. The whole experiment will not take more than two hours.

3.1.3. Measures.

As mentioned previously, in order to evaluate the constructs encompassing our variables, the establishment of suitable measures is crucial. We have successfully identified validated multi-item measures that are relevant to our constructs. The measurement tool devised for seamless integration with our evaluation model is outlined in Table 2. This instrument will be distributed to the participants, enabling them to assess both the guidelines (which we be evaluated by the subjects) and the resulting BPMN model through a 7-point Likert scale (which will be done by the domain experts), encompassing responses ranging from 'strongly disagree' to 'strongly agree'.

The constructs for Perceived Ease of Use (PEU), Perceived Usefulness (PU), and User Satisfaction (US) are derived from Information Systems (IS) research, specifically focusing on IT adoption, IS effectiveness, and user satisfaction, where they are commonly applied, the measure for PSQ was developed by Poels et al [31]. The items for Perceived Ease of Use (PEOU) were initially suggested by Gemino and Wand [32], drawing inspiration from Moore and Benbasat's [33] measure for the perceived ease of use of IT innovations. Additionally, Moody's [34] Perceived Usefulness (PU) metric, which in turn is based on Davis' [35] PU measure within the Technology Acceptance Model (TAM). To assess User Satisfaction (US), Seddon and Yip's [36] overall User Information Satisfaction measure was used. This particular measure was later modified by Dunn and Grabski [37] for evaluating satisfaction with the use of conceptual modeling notations. We use the adapted version from [26] that uses all these constructs in one instrument.

3.1.4. Execution.

The experiment took place in a dedicated time slot of two hours (2hr) and it was done online. Since there were students from two different courses and countries, we needed to give an extra lecture on e^3*value* to the students of Universidade de Sao Paulo (USP), because the focus

Table 2
Measurement instrument for the experiment. Adapted from [26].

PEU_1	It was easy for me to understand what the guidelines/derived model was trying to accomplish.	PU_1	Overall, I think the guidelines/derived model would be a better option than a textual denotationion of the business process domain.
PEU_2	Using the guidelines/derived model was often frustrating.	PU_2	Overall, I found the guidelines/derived model useful for understanding the business process domain.
PEU_3	Overall, the guidelines/derived model was easy to use.	PU_3	Overall, I think the guidelines/derived model improves my performance when understanding the business process domain modelled.
PEU_4	Learning how to interpret the guidelines/derived model was easy.	PSQ_1	The derived model represents the business process domain correctly.
US_1	The guidelines/derived model adequately met the information needs that I was asked to support.	PSQ_2	The derived model is a realistic representation of the business process domain.
US_2	The guidelines/derived model was not efficient in providing the information I needed.	PSQ_3	The derived model contains contradicting elements.
US_3	The guidelines/derived model was effective in providing the information I needed.	PSQ_4	All the elements in the derived model are relevant for the representation of the business process domain.
US_4	Overall, I am satisfied with the guidelines/derived model for providing the information I needed.	PSQ_5	The derived model gives a complete representation of the business process domain.

of their course was mainly BPMN. A two hours (2hr) lecture was given regarding the main e^3*value* concepts and notations. The students were then given the pre-test, most of the students finished their knowledge test in twenty (20) minutes. After they were given the specifications (in e^3*value*) of the case (music case – IPR), along with the guidelines. We also judge necessary a short explanation about the domain, however this was done using a video in which one of the domain experts explain in general how IPR collection is done. We did not want to put the explanation in text since this would bias the derivation to the BPMN model. At the end the subjects received a post-test which they finished in less than ten (10) minutes.

3.2. Experiment results

Prior to the data analysis, we checked the subjects pre-test results and found them with similar competencies, though there was a difference in their distribution. We use t-tests to analyze the

significance of validity and completeness. Table 3 presents denotationive statistics regarding this comparison.

Table 3
Assessment of PSQ measure (measurement model)

Items	Load ratio	t-statistic
PEU_1	0.79	2.02
PEU_2	0.80	3.51
PEU_3	0.85	4.24
PEU_4	0.70	1.44
PU_1	0.76	1.43
PU_2	0.88	2.24
PU_3	0.80	1.89
US_1	0.74	2.89
US_2	0.83	3.45
US_3	0.87	2.58
US_4	0.91	3.04
PSQ_1	0.64	2.21
PSQ_2	0.66	3.51
PSQ_3	0.68	4.24
PSQ_4	0.67	1.44
PSQ_5	0.69	1.43

Initially, the reliability of individual items was evaluated by analyzing their loadings ratio on the designated constructs (refer to Table 3). Items are deemed reliable for their intended construct only if they exhibit loadings of 0.60 or higher, and such items should be included in the final measurement model. All items pertaining to Perceived Ease of Use (PEU), Perceived Usefulness (PU), and User Satisfaction (US) showed satisfactory reliability. The validity of the PSQ measure is determined by whether the coefficients of the PSQ indicators significantly differ from zero [38]. When treating the construct as the dependent variable, formative indicator coefficients can be likened to regression coefficients, with the items acting as independent variables. Indicators whose coefficients do not significantly deviate from zero might be deemed redundant by respondents, may correlate highly with other indicators, or might not be relevant to the specific construct, thus warranting their removal from the model. The results reveal that all PSQ indicators have exhibit coefficients that are significantly non-zero ($p < 0.05$).

The analysis indicates that PSQ judgement is caused by PSQ1 ($t = 2.21$), PSQ2 ($t = 3.51$), PSQ3 ($t = 4.24$), PSQ4 ($t = 1.44$) and PSQ5 ($t = 1.43$). Therefore PSQ elements are relevant formative indicators of perceived semantic quality and were retained to confirm the hypotheses.

The analysis indicates that all paths were significantly different from zero at the 0.05 level or lower, thereby supporting the proposed relationships among the four dimensions used for assessing user evaluations of conceptual modeling notations. The findings corroborate the predicted significant impact of PSQ on User Satisfaction (US). A link between PSQ and Perceived Usefulness (PU) was also observed, although its effect was less pronounced compared to that on US. Perceived Ease of Use (PEU) appeared to play a more crucial role in determining PU, evidenced by a marked and statistically significant influence of PEU on PU in both studies. PSQ and PEU jointly accounted for the variation in PU. Additionally, the direct impacts of PEU on US

and PU on US were substantiated, both showing comparable levels of significance. Alongside PSQ, these factors collectively accounted for the variance in US.

4. Discussion and Future Work

The experiment proposed a PEU–PSQ–PU–US measurement instrument, it provides a practical evaluation framework that combines conceptual modelling quality variables related to perceptions of pragmatic quality, semantic quality and usability, as well as satisfaction outcomes. Our testing of the measurement tool empirically confirmed the proposed theoretical relationships among these quality dimensions. The data showed that the perceived semantic quality (PSQ) of a notation significantly affects the user's perceived usefulness (PU) and satisfaction (US) with the notation. Furthermore, it was established that a user's overall satisfaction with a conceptual modeling notation (US) is influenced by its perceived usefulness (PU) and the perceived ease of use (PEU), reflecting the model's pragmatic quality. Additionally, the perceived ease of understanding (PEU) was found to be a key determinant of its perceived usefulness (PU). This only assess the guidelines positively, since US and PEU is directly related to how the guidelines performed during the experiment. The assessment on PSQ of the models by the domain experts corroborates that the models created using the guidelines were valid and reliable. While the experiments conducted lend support to the hypothesized associations within the quality model for user evaluations of conceptual modeling notations, it is evident that the guidelines is still in its nascent stage and requires additional testing, validation, and perhaps even redefinition before definitive conclusions can be made and its external validity improved. Future investigations could explore different tasks and models, and potentially involve field studies with practitioners rather than students, to evaluate the model and the guidelines in varied contexts.

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