Evaluating the Business Value of Information Technology

Case Study on Game Management System

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***Abstract*—Evaluating the multidimensional and dynamic nature of IT business value is a continuous challenge. This paper examines how system dynamics can be used in evaluating IT business value in a company level. We approach IT business value as a web of impacts, where benefits and sacrifices are ultimately evaluated against company earnings logic. This study is based on an action research and covers a pilot project within two co-operating companies. System dynamics was utilised to construct a value creation model for an existing Gaming Management System. This value creation modelling covered two dimensions: 1) structural evaluation of IT impacts with cause-and-effect models, 2) dynamic evaluation and simulation of value realisation over time. As a result, value creation modelling was able to provide a visual overview of how IT impacts were linked to business value through value paths, and how much and when value was realised. Value creation modelling enabled prototyping of value realisation that can provide value based insights for development activities like requirements elicitation and analysis. The examined approach proved its potential for providing a common language for technology and business parties, thus improving IT business alignment.**

***Index Terms* —IT business value, evaluation, system dynamics**

I. Introduction

Various drivers exist for companies to evaluate the business value of their IT [1]. IT business value guides IT investment decisions, focuses and prioritises development requirements [2], and realistic insight on IT current and potential value is the cornerstone for continuous improvements of IT business alignment. In this paper, we approach the IT business value as an aggregation of benefits and costs. The benefits and costs are the effects of IT impacts both on the process and usage level as well as on the company final performance measurement level. With IT we cover the combination of infrastructure technology, software technology and applications.

IT business value evaluation is challenging and the topic has been on both research and practitioner agendas for more than two decades [3]. Multiple reasons drive the challenges of evaluating IT impacts and estimating the value of those impacts. For example, the impacts of IT can be indirect and the business value realisation is a sum of interrelated factors on different levels of company activities and stakeholders [4, 5]. From the value evaluation point of view, IT benefits and costs are separated in time and space. The above mentioned challenges of IT value evaluation form the background and the research problem of this study. Our research goal is to explore how *system dynamics (SD)* methods and modelling can be used to better understand the construction and realisation of IT business value in a company context. Illustrated by a case study, we explore *how system dynamics can be used in evaluating IT business value*.

According to the systems thinking approach [6], we treat IT as a part of company level business system and IT business value is evaluated against business system purposes. Business system purpose is approached through the company business model and its focal element, earnings logic. System dynamics (SD) modelling is used to understand the elements and their interconnections for value creation, as well as the dynamics of value realisation over time.

The structure of this paper is the following. Section II (*Related work*) investigates the challenges of IT evaluation from the value realisation and business value viewpoints. The system dynamics (SD) approach is introduced with aspects promoting its suitability for our current problem domain. Section III (*Research design*) presents the research empirical case setup and the way we applied action research methods. The results of this research are formulated through three phases. The first phase, *Problem diagnosis* (Section IV) elaborates the IT business value structure and dynamics as well as investigates the theoretical feasibility of SD for matching the evaluation challenges. The second phase, *Action intervention* (Section V) focuses on the pilot case and how SD was utilised in understanding the value creation mechanisms of the pilot company Game Management System. The third phase, *Reflective learning* (Section VI) summarises the applied framework of matching business system, SD modelling methods and IT value creation as a modelling domain. Reflective learning covers also some important experiences confronted during the value creation modelling iterations. In Section VII (*Discussion*), the results are positioned within the IT/IS research field and implications for both practice and research are presented. Further research is proposed to achieve better understanding of how well and in what kind of circumstances SD is feasible to evaluate the IT business value. Section VIII (*Conclusions*) concludes the contributions of this study.

II. RELATED WORK

A. IT Business Value and Business Model as a Goal Setting

IT business value is defined as the contribution of IT to the company performance [1,3]. In general, the business value subsumes the company goal attainments, required efforts or sacrifices and the economic worth [7]. Thus, when studying IT impacts on business value, both benefits and costs (intangible and tangible) have to be evaluated against the degree of the met business goals, and ultimately that goal attainment is judged by its economic worth for the company.

This study investigates IT at an individual IT application level where the directness or indirectness of the impacts of IT on the business value depends on the purpose of IT. The purpose of IT can focus on transactional, informational, strategic or transformational usage [8], or the position of IT utilisation resides on product or service design, production or delivery phases [9].

We utilise the goal driven principles for the IT business value evaluation and explore the business goals from the business model of a company. According to Teece [10], a business model "*reflects management's hypothesis about what customers want, how they want it, and how the enterprise can organize to best meet those needs, get paid for doing so, and make a profit*". The company business model should reveal the concrete ends that are supposed to be the final targets for IT impacts. Nenonen & Storbacka [11] synthesise business model literature to include following ingredients:

- customer value creation i.e. how the company creates value for the customer,
- earning logics i.e. how the company yields a profit from its operations,
- value network i.e. external relationships for value creation,
- resources and capabilities,
- strategic decisions about competitive positioning and target markets or customers.

From the point of view of economic worth, we consider the company earnings logic as a reference point for reflecting and linking IT business value. Depending on the purpose of IT under evaluation, it is possible to add other elements from the business model as a reference point for IT impact evaluation, although the highest level evaluation target would be on costs, revenue and profits level (i.e. earnings logic).

B. Challenges and Approaches Related to IT Evaluation

Various motives exist for understanding the business value of IT. IT is an asset that requires an investment decision, returns of IT investments are targets for monitoring and improvement planning [12], and IT expected value focuses implementation decisions and prioritises development requirements [2]. The IT impacts on benefits, costs and business value have been studied for decades (see, e.g. [3,12,13]). Although IT productivity paradox can be seen as solved and, based on empirical research, IT undoubtedly has positive overall effects [14, 15], the evaluation of IT value remains a challenge for both researchers and practitioners [14].

A few difficulties in evaluating IT as an investment differentiate it from evaluating traditional tangible assets or human capital [16]. At first, IT is not utilised in a vacuum but IT utilisation is a socio-technological phenomena [12]. The returns of IT are, in most cases, dependent on multiple other factors (complementary factors) at different levels of organisation [3,5,17]. Additionally, the spectrum of IT usage targets is wide, ranging from, for example, transaction efficiency to strategic differentiation issues [8,9,18].

As a summary, the following aspects related to IT impacts and evaluating these impacts are repeated in the literature:

- **Delays and dynamics**: IT benefits and costs are realised over varying and extended period of time [19,20]. Value realisation is dynamic and single snapshot measures do not necessarily provide a realistic view about the business value [17].
- **Complementarity**: IT value realisation is affected by multiple factors enhancing or hindering the impacts [3,5,16], outcomes depend on how IT is used [4,15,22] and how organisational changes related to IT usage are implemented and managed [1,4,17,23].
- **Intangibility**: both benefits and costs can be complicated to identify and quantify, especially when those are related to organisational capabilities or strategic goals [20,23]. Intangibility is, in many cases, related to the broad scope and indirectness of IT impacts [23,24].
- **Indirectness and scope**: the links between IT immediate impacts and observed benefits/costs can form multilevel cause and effect chains [4,5].
- **Measures and units of analysis**: conventional input-output accounting measures and methods fail to cover the complexity of IT impacts [14,25]. Variables being measured are affected by external factors and it is challenging to isolate the direct contributions of IT [20].

Most of the solutions for evaluating the IT business value build on recognising the above mentioned aspects to a certain degree [e.g., 4,21]. Conceptual level solutions, for example, aim for balanced measures combining both tangible and intangible or perceived measures [21,14]. IT usage purpose, e.g. transactional, informational or strategic, can also affect the chosen measures [8,26,27]. In addition to focusing only on technology implementation issues, the existence of many complementary factors affecting IT success (e.g. processes, employee skills) persuade also considering organisational change management issues [4,22]. Many classifications of IT benefit [e.g., 18,28] or cost sources [28] can act as checklists for IT evaluation purposes.

DeLone & McLean Information System success model [29] or IS-measurement impact model [25] are examples of general purpose models that recognise multilevel and chained nature of IT impacts. Examples of practical level evaluation frameworks include balanced IS scorecard [30], Project performance scorecard [32], Benefits Dependency Framework [4] or Systems analysis, accounting and strategy framework [21].

Giaglis et al. [32] suggest that the evaluation of IT benefits is an incremental learning process. This evaluation should begin by first modelling direct and quantifiable benefits, after which it is easier to go deeper with more aggregated and complex benefits, thus gradually making intangible benefits more quantifiable. Chan [17] also sees IT evaluation as a company and target IT specific evolution where the evaluation system itself is developing together with the IT system. Chan suggests that, in addition to asking "*What value do IT investments provide?*", a related set of questions should also be considered: "*Why, where, when, how, and to whom do these investments provide value?*". Chan's set of questions promote a holistic approach for IT value creation, thus motivating our study towards systems thinking and system dynamics.

C. System Dynamics and IT Evaluation

System dynamics is based on systems thinking. According to Senge [33, p.68], systems thinking is *"... a discipline for seeing wholes... a framework for seeing interrelationships rather than things, for seeing patterns of change rather than snapshots*.". The system is, as defined by Meadows [34, p.188]: "*A set of elements or parts that is coherently organized and interconnected in a pattern or structure that produces a characteristic set of behaviours, often classified as its 'function' or 'purpose'*". The purpose of the system is related to the system boundaries, which are dependent on the observer's viewpoints. In addition to system overall purpose, it is also vital to identify the usage purpose for the model [6, p89]. System models are always reflections and abstractions of a real world, and the usage purpose of the model defines the appropriate scope and the level of details in the model.

System dynamics (SD) can be seen as one methodology in the systems thinking approach. SD is used to model system structures and the dynamic behaviour over time caused by the interrelationships within the structures. System modelling is supported by two kinds of models: 1) cause and effect causal loop and feedback diagrams (CLD) [35,36,6], and 2) stock-and-flow diagrams (SFD) for presenting the speed of system internal changes, delays and accumulations of issues [6]. The structural analysis with causal loop diagrams is called *qualitative SD* and dynamic analysis with stock-and-flow diagrams is *quantitative SD* [37-39].

Qualitative SD aims to capture both tangible and hidden assumptions of the factors behind the system under investigation. Qualitative SD can be used alone as a problem structuring and group learning method [e.g., 40], but quantitative SD is able to provide insights into the system dynamic behaviour [35]. Quantitative SD formalises the elements of qualitative SD as variables and mathematical equations. Quantitative SD models can be used to simulate the system behaviour: to test different system configurations, to find leverage points in the system structure, or to perform sensitivity analysis for system variables [6]. Qualitative and quantitative SD is supported by software tools such as Vensim or Powersim.

The idea of using SD as a method for evaluating IT and IT impacts is not new. Wolstenholme [41] encourages "holistic modelling approach" for information system benefits assessment and uses SD as a framework for studying complex and dynamic interactions, as well as exploring the effects of strategic changes within information system. Clark et al. [42] use SD to test the linkage of information attributes (accuracy, timeliness, relevance and reliability) to economic performance measures (cost, profitability and efficiency). Mutschler et al. [43,44] introduce SD modelling based EcoPOST cost analysis framework for process-aware information systems. In addition to static cost factors, EcoPOST also covers dynamic cost factors (e.g. re-design of business processes) and dynamic impact factors (e.g. process and domain knowledge or end user fears).

Georgantzas & Katsamakas [45] have reviewed the literature that focuses on the combination of information systems and SD. These authors categorise the literature based on the level of examined interactions: how information systems impact individuals, groups, organisations and finally markets. When we reflected our study against Georgantzas & Katsamakas categorisation, our aim was to recognise IT impacts both on individual and group levels while developing an organisational level (i.e. company level) understanding on value creation.

Thus far we have presented a motivation for combining IT evaluation as a problem domain and SD as a tool for approaching these evaluation problems. Although this combination is somewhat familiar on a conceptual level in recent literature, an apparent gap seems to be present in empirical research regarding utilisation and feasibility of SD for IT business value evaluation. Value as a multidimensional concept is also recognised as a central factor for software and IT development and decision making within Value-based Software engineering [2]. However, based on authors' own industrial experiences and research collaborations, the usage of practically feasible methods for the IT value evaluation during requirements engineering analysis and negotiation phases are scarce. The above mentioned gaps in research and needs from practitioners motivated our research for exploring the utility of SD for providing knowledge about value creation, equally for investment decisions, development priorities and for a baseline for long term improvement plans.

III. Research Design

A. Case Description and Unit of Analysis

This paper addresses the means and experiences of applying system dynamics for understanding IT business value. This study is conducted in joint collaboration of researchers and practitioners. Practitioners provide research context via two separate but related companies: 1) *Host Company* – the primary research partner 2) *Pilot Company* – the customer of Host Company and the provider of the target IT system for piloting the IT business value evaluation.

Host Company is strongly motivated with the research subject because its own service development and customer projects are involved with improved knowledge about the IT value. The mission of Host Company is to ensure the success of the IT investments for its customers. Its service spectrum covers the lifecycle of IT from the quality of requirements to ensuring the quality of IT service operations. Host Company is developing its offering to better match the value of its customers' IT benefits and value creation. As part of value based service development activities, in spring 2013, Host Company initiated a pilot program for selected customers. The goal of the program was to develop and test the IT value creation modelling methods together with the customers and to use new value insights to guide and focus IT monitoring and quality assurance solutions.

Finnish national betting agency was selected as the first Pilot Company. This Pilot Company provides lotteries and sports betting games. As a target IT system for piloting, the Game Management System (GMS) was chosen. GMS is a support system related to the delivery processes of nearly all Pilot Company game offerings, covering both lottery and sports games. GMS impacts are most tangible with sports games where it covers the entire lifecycle of game delivery, starting from the creation of wagers, defining odds, changing, closing and managing the wagers, as well as handling the gaming results and winning data. During its many years of evolution, GMS has substituted several specific applications and considerable amount of manual work processes. Despite its criticality on operative gaming processes, Pilot Company representatives faced challenges in arguing and concretising GMS maintenance and development decisions in terms of tangible business benefits and value. One of the pilot goals was to provide Pilot Company better knowledge about the value of GMS, in order to make more informed decisions about further investments.

The unit of analysis in the study is the utilisation of system dynamics for understanding the business value of the Pilot Company GMS system. This unit of analysis covers pilot preparation activities within Host Company, pilot implementation activities in a shared context of Host and Pilot companies and, finally, the pilot retrospective within Host Company (see Fig. 1).

B. Research Approach and Process

Our research goal was to explore how system dynamics can be used in evaluating IT business value. The research partner (Host Company) had a practical need for value evaluation solutions, and the preliminary research before this study had uncovered the potential of SD for linking the IT impacts and the business value evaluation.

Action research was selected as a research approach to acquire understanding of SD utility in an actual pilot case. Action research aims to solve current practical problems while expanding scientific knowledge [46, p55]. As the action research is conducted in real life settings together with the practitioners, it is ensured that the action part focuses on practically relevant issues. The research part separates the action research from consultancy, meaning that the problems investigated are also of interest to other researchers and the lessons learned from problem solving can be generalised to relevant theories [46, p.62-63]. This study follows an iterative, three phase research process suggested by Avison et al. [47] and applied in the case context as depicted in Fig. 1. The reported phases occurred from March 1, 2013 to December 31, 2013 and the pilot phase in Pilot Company was conducted in four months June 1 – September 30.2013.

Problem Diagnosis Phase validated the research relevancy both from the practical and research points of view. For practical relevancy, SD modelling prototyping and Host Company interviews were used. For research relevancy, literature studies showed the potential of linking IT evaluation challenges and SD, but also highlighted the research gap for approaching IT business value with means of systems thinking.

Phase	Description	Context & methods
Problem Diagnosis	Analysing current situation and defining the problem	Context: **Host Company** • Interviews • Prototyping • Literature reviews
Action Intervention	Planning improvement actions and implementing the planned actions	Context: **Pilot Company** • Workshops • Modelling iterations
Reflective Learning	Analysing the effects of the improvement actions and identifying learnings	•Interviews •Pilot retrospective •Literature reviews

Figure 1. Research activities and methods of the study.

Action Intervention Phase focused on piloting the business value evaluation for GMS system of Pilot Company. This phase included planning and executing the series of three workshops and iterating the value creation modelling together with Host and Pilot Company teams.

Reflective Learning Phase focused on analysing the experiences of the pilot. Literature reviews were continued for reflecting and reporting the SD modelling experiences with the existing research knowledge. Due to space constraints, the reported experiences focus on value creation modelling substance issues, not on the facilitation of modelling process.

All three phases involved researchers and Host Company team (*Host Team*) close co-operation. Action intervention involved also shared efforts from Pilot Company team (*Pilot Team*). *Host Team* included the Project Manager and the Senior Analyst in execution roles and the Service Production Manager and the Customer Account Manager in steering group roles. *Pilot Team* had five members from different GMS stakeholder roles: gaming business owner, gaming operations and management, IT management, gaming business development and GMS R&D. The research team had two persons, one participating actively in all research phases and in all pilot execution tasks, and the other researcher who participated in two (out of three) reflective learning interviews and in the analysis of the pilot retrospective.

C. Data Collection and Analysis

Data collection methods covered interviews (10), workshops (3), working hour statistics, prototyping, meeting memos and offline communications. Problem Diagnosis Phase included seven interviews with Host Company employees who were working in quality assurance, system analyst or project management positions. The interviewed employees had an average of 19 person years working experience in the IT field. In Reflective Learning Phase, three group interviews were conducted: one with Host Team and two with Pilot Team. Problem diagnosis interviews were conducted by one researcher and two out of three reflective learning interviews had two interviewing researchers.

Three workshops together with Host and Pilot Teams during Action Intervention Phase were used for gathering input data for the iterative value creation modelling and for evaluating both the modelling outputs and the facilitation process of modelling. Each workshop had formal feedback questions at the end of these sessions. All the interviews and workshops were recorded, transcribed and analysed with ATLAS.ti analysis software. Data analysis continued in writing a retrospective report for Host Company and in the writing process of this paper. All interview and workshop analyses were reviewed together with the researchers.

IV. Problem Diagnosis

Host Company had a goal for grounding their solutions – with reasoning, focusing and pricing - increasingly on customers' IT capabilities on value creation. In order to enable this, Host Company wanted to develop skills and robust practices for linking IT impacts to different organisational levels and finally to business value. The solution development of Host Company had identified the following practical requirements for the IT evaluation approach:

- Methodical – when grounded on the existing methods and practices, it would be easier to develop and maintain the required skills and build prescriptive evaluation guidelines.
- Communication support – visual aids for structuring complicated situations would facilitate learning, knowledge sharing and commitment within different parties.
- Tool support – availability of existing tools for applying the evaluation methods would enhance the solution delivery capabilities.

Based on the initial value evaluation prototypes, systems thinking principles and SD were seen as potential candidates for the value evaluation methods base. When considering from the methodical and tool perspectives, SD is supported by modelling and analysis tools such as Vensim or Powersim, text books are available [e.g., 6] and active user communities exist (e.g. www.systemdynamics.org). Empirical experiences about SD applicability for group learning and knowledge sharing is also available [e.g., 40, 48].

Host Company employees were interviewed to understand the current state of: how customer systems were evaluated, what kind of practical challenges were present and how IT success evaluation and valuing were implemented. As a result, interviewees saw the complexity of IT as a real challenge. Another observation was that the IT project success was very seldom evaluated by the realised value of the IT, but most often on the level of the IT project budget, schedule as well as the technical and use level requirements. Despite of this current status, interviewees saw that their customers were interested in longer time horizon with IT success evaluation, but the value based evaluation was perceived as very challenging. Finally, the interviews revealed the lack of company level common methods for value evaluation.

The complexity of IT impacts and evaluation of the business value of these impacts was seen as a challenge both by Host Company and in literature [e.g., 5,12,27]. One of the goals for the IT business value evaluation was to link benefits and costs from different organisational levels together. Referred to that goal, the complexity problem was simplified as: *IT impacts on benefits and costs are often separated by time and space*. 'Separated by time' means that the IT impacts are observed with varying delays and these delays can be different for benefits and costs. Delays are caused, for example, by multiple organisational levels, cause-and-effect chains and cumulation between the IT first hand impact and the actual measuring point of an observer who is interested in certain benefits and/or costs. These chains of effects and different organisational observation locations represent structural complexity, i.e. 'separated by space' perspective.

The above mentioned simplification regarding the complex nature of IT business value evaluation was used as a basis for considering the feasibility of SD modelling. Together qualitative and quantitative SD would cover both angles of 'separation by time and space' complex nature. By focusing on the business system structure, i.e. elements and their relations, qualitative SD would help in answering **how** IT impacts on value creation. Quantitative SD would be the tool for understanding and simulating the dynamic value realisation over time, thus answering **how much** value and **when**.

Both evaluation prototypes and literature identified challenges with SD usage. The causal loop diagramming provides only qualitative representation of the feedback structure of the system and to obtain more rigorous insights into the system behaviour, quantitative SD with simulation is needed [35]. However, quantitative SD models can be very demanding in terms of modelling skills, time, resources, and availability of data [36]. Availability and uncertainties of data are often related with soft variables, which can be difficult to formulate as equations and for which numerical data is not easily available [38]. Coyle [38] raises the concern that uncertainties of simulation may lead to seriously misleading results. Although, according to Homer & Oliva [37], even in those cases with high uncertainties, formal simulation can provide valuable insights by indicating what kind of information would be required in order to make firm conclusions possible.

Another challenge is related to system and modelling boundaries. Defining the model boundaries and deciding what is treated as endogenous variables (i.e. explanations for phenomena which arise within the system) and what as exogenous variables (i.e. arising from outside), is one of the first activities in the system modelling [6, p.95]. Failures in expanding the boundaries of our mental models lead to too narrow system model boundaries. Too narrow model boundaries, either regarding the time horizon or cause and effect interferences, may restrict us to recover the most influential structures causing important behavioural patterns [49]. However, broadening the system scope increases the required work effort and the required reference data for modelling. Thus, finding the right balance for the system model boundaries seems to be a critical task. According to Sterman [6, p.87], setting the system boundaries and modelling details is an iterative learning process including modelling, testing and analysing the insights from the models.

Based on the insights gathered during Problem Diagnosis Phase, SD was seen as a feasible method in complex situations to highlight dynamic and counter-intuitive effects with non-linear delays and when continuous modelling approach would be preferred over discrete event based modelling [41,50]. Due to its iterative nature, SD utilisation cost-benefit ratio was assumed to improve in settings where modelling and its benefits could be linked to IT lifecycle thinking. The above mentioned criteria were used in Action Intervention Phase for selecting the pilot case and the target IT system (GMS).

V. Action Intervention

Action Intervention Phase focused on testing the SD utility for evaluating the business value of Pilot Company Game Management System (GMS). SD modelling was used to build a value creation model. The value creation model covered both structural and dynamic views to value: 1) **how** IT impacts value creation, i.e. the system elements and interactions within the elements, and 2) **how much** and **when** value is realised over time. In practice, this value creation model was a combination of qualitative causal loop diagrams (CLD) and quantitative stock-and-flow diagrams (SFD). The goals for the value creation model were 1) for Pilot Company to illustrate and concretise GMS role and importance for the gaming business, 2) for Host Company to provide experiences on how value creation modelling would guide measuring and monitoring of the IT value creation.

The piloting was scheduled with three workshops and modelling iterations between these workshops. The topics for the workshops were: 1) Getting the overall picture of the business system with GMS as a part of that system, understanding goals for the pilot and setting initial system boundaries, 2) System structure (elements and relations) validation and focus for further modelling, 3) System dynamic behaviour validation and metrics for value monitoring. The following sections represent how SD modelling was linked with Pilot Company business system.

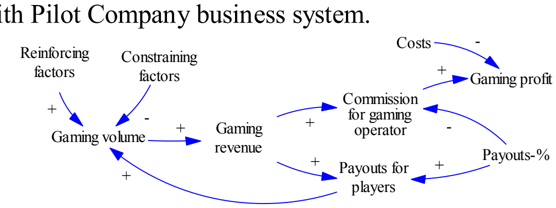

Figure 2. Gaming business earnings logic model. Plus and minus signs indicate the link polarity: '+' for a change to the same direction and '–' for a change to the opposite direction.

The modelling target was a business system that was initially divided into three layers: 1) earnings logic of Pilot Company gaming business, 2) central elements for implementing or supporting the earnings logic (e.g. processes, functions, phenomena), 3) GMS IT services supporting or enabling the central elements. The earnings logic was used as a starting point for modelling, thus ensuring that the IT impacts would be linked to actual business level goals and valuing measures. Figure 2 represents an earnings logic of Pilot Company gaming business. The gaming volume increases the gaming revenue which in turn is shared between the gaming operator and the players. The gaming profit is the remaining share after the costs are subtracted from the share of the gaming operator.

The following phase identified those elements which either implement or support the execution of the earnings logic. Gaming management and delivery process were used as a source for finding the elements which can link GMS impacts to earnings logic. For example, the most tangible impact of GMS to gaming revenue was realised through the creation and management of wagers. GMS decreased the manual work within the gaming process, which in turn allowed larger gaming target volume compared to the fictional situation where GMS would not be in place. Examples of more indirect impacts of GMS for gaming revenue were through the improved quality of wagers or through decreased human errors in the gaming process.

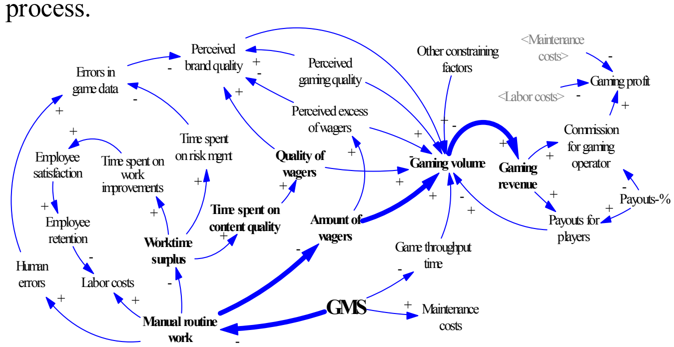

Figure 3. Snapshot of the structural model for linking GMS impacts with business system. Example value path is bolded.

Figure 3 represents a simplified version of the GMS value creation model on a cause-and-effect structural level. The model also includes the visualisation of a *value path*. Value path was used as a concept for representing the impact chain of elements in a value creation model, from IT to a specific end point valuing element. Such an endpoint is used to make the benefits tangible, for the benefits to be further comparable and linkable to the costs of creating that benefit. The value path example in Fig. 3 is related to creating extra sales by the improved efficiency in the creation of wagers. The impact chain for the value path goes through the amount of manual workload, amount of wagers, gaming volume and finally to the gaming revenue. Another value path example covers GMS impacts on the quality of the wagers. In order to have a sustainable gaming revenue, Pilot Team reasoned that the gaming volume should be based on both a proper amount of available wagers and a proper quality of wagers (e.g. topicality and attractiveness of odds for wagers). The balancing of volume and quality was an example of systemic interaction that was recognised from the structural level value creation model.

The previous example of structural value creation model with value paths answered how GMS impacts business value. In order to understand how much and when this value was realised, modelling was continued on a dynamic level. In dynamic modelling, the elements of structural model were presented as variables and enhanced with stock-and-flow characteristics. Furthermore, the relationships between the elements were represented as mathematical equations.

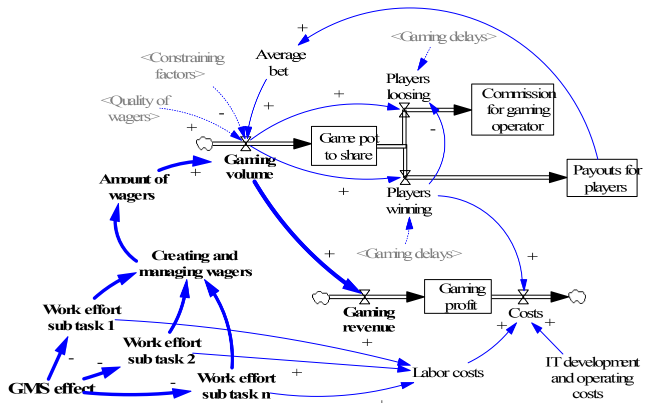

Figure 4. Snapshot of the dynamic model for representing GMS impacts on earnings logic level. Rectangles (stocks) are dynamic elements the values of which are determined by the accumulated changes over time. Arrows with valves represent inflows and outflows affecting the values of the stocks.

Figure 4 illustrates how GMS impacts on the gaming process workload and the amount of wagers are linked to the gaming revenue and the gaming profit. The dynamic model snapshot covers the value path illustrated in Fig. 3. The workload data needed in dynamic modelling was based on Pilot Team's estimations for two scenarios: how much work effort in hours is required for running the gaming process with GMS and how much work would be required to achieve the same output without help from GMS. Based on these two scenarios, the dynamic model was used to simulate GMS impacts on gaming revenue. The same model was also used to simulate the costs of compensatory work caused by GMS downtimes. Simulated cost and value estimations provided concrete ideas of possible magnitude of monetary GMS value.

VI. Reflective Learning

Reflective Learning Phase focused on analysing the experiences from the GMS piloting phase and reflecting the learnings against literature. Both Host Team and Pilot Team were interviewed in order to obtain feedback on the pilot workflow issues and the suitability of systemic approach. Workflow issues covered workshop facilitation, communication and resourcing aspects. Systemic approach elaboration covered issues such as intuitivity of used terminology and relevancy of outputs. In the following analysis we focus on the systemic approach and SD usage experiences as well as piloting outputs.

Piloting outputs. From the outputs point of view, Host Team considered piloting a valuable proof-of-concept for the value creation modelling. SD was a feasible method in concretising IT business value and identifying measures for monitoring value realisation. Pilot Team saw the structural value creation model with value paths as the most important output. The structural model was able to provide a value based overview of the role of GMS within the business system. The overview was appreciated in communication between the technical and business parties.

The framework. Figure 5 summarises how SD was utilised for the IT business value evaluation. SD provided the basic methods for reflecting the reality of business system into the structural and dynamic models of value creation. The analysis of the business system was initiated from the business level goals, which were discovered from the business model and especially from the earnings logic. The business system analysis was continued by inspecting processes, usage and IT services for linking the IT impacts with value creation. The value creation model was implemented on two interconnected levels of value structures and dynamic value realisation. The qualitative SD with causal loop diagrams facilitated structural modelling and the quantitative SD with stock-and-flow diagrams enabled dynamic modelling and simulations.

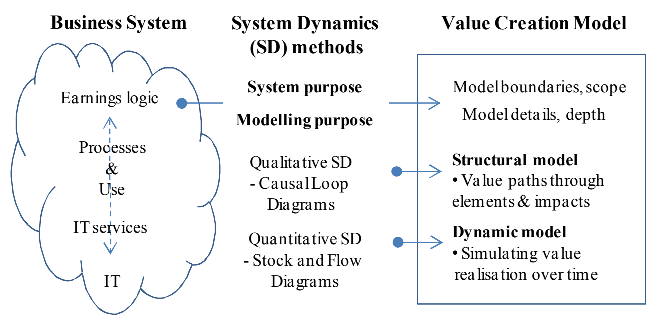

Figure 5. The framework for utilising SD for IT business value evaluation.

Importance of purposes. Two kinds of purposes influenced the scoping and focusing of modelling: 1) the purpose of the system, and 2) the purpose of the modelling itself. The purpose of the system was identified from the earnings logic, and that ensured the IT impact elaboration against the business value. In general, setting the system boundaries defines the highest order value evaluation level that can be reached by modelling the system under evaluation. By calling the system under evaluation a business system, the expectations for the purpose of the system are set to the correct level for the IT business value evaluation.

The purpose of modelling was closely related to the question "*how good is our model, should we continue further or is this enough?*". The purpose of modelling can be process oriented or output oriented or both. The process oriented purpose promotes knowledge sharing and group learning about the system. The output oriented purpose focuses on the usage of the models in supporting decision making. In the pilot, modelling had both process and output oriented purposes, but the output oriented purpose was not explicit in the beginning. The level of explicitness of the final usage goals of the models affected the level of difficulty when deciding the proper level of details and accuracy in modelling. The purpose of modelling also affected the balance of effort used for structural and dynamic modelling.

Interplay of modelling levels. Based on Host Team and researcher experiences, cost-effective balance between structural and dynamic modelling was an important issue. Using causal loop diagramming for identifying system elements and defining the system structure was an intuitive opening activity. Enhancing structural causal loop diagrams with the dynamic stock-and-flow diagramming supported the understanding of cumulations and delays. When advancing the dynamic modelling further, the usage of data and mathematical equations in stock-and-flow model simulations allowed the testing of different system configurations and the observance of the leverage points. The dynamic modelling also provided feedback to the structural modelling level by indicating fuzziness in cause-and-effect relations or suggesting the division of too abstract elements into more atomic elements. However, the benefits of the dynamic modelling required considerable extra effort both in technical modelling (e.g. semi-programming and debugging Vensim-models) and collection and analysis of the required input data for modelling.

Iterative modelling. The appropriate scope and depth of dynamic modelling was very open in the beginning of the pilot, as the output oriented purpose of the modelling was not set explicitly. During the modelling iterations, simulation gradually focused into one value path; GMS impacts to workload and to gaming revenue. Pilot Team interviews in Reflective Learning Phase revealed the consequences of the partly fuzzy modelling purpose. Some members of Pilot Team were very satisfied with the modelling outputs as they saw the structural cause-and-effect diagrams as the most important and usable result. The other members of Pilot Team were satisfied with the structural model as an overview and communication tool, but they wished that the models were more detailed in order to provide more game type specific insights (e.g. different sport betting games). However, Pilot Team members felt confident for the potential of dynamic modelling and they were ready to invest more work in the future for acquiring better data for more detailed modelling. As the current level of the dynamic model covered only one value path, further modelling iterations would be necessary for understanding the leverage points and the desired balance of, for example, the volume and quality of wagers. The structural modelling of the interactions of these crossing value paths provides only hints about the leverage points and balancing aspects, but the dynamic modelling with simulation would be required for more concrete insights.

As the snapshot of the dynamic model demonstrated (see Fig. 4), GMS impacts were derived to high level business goals. The other possible direction for deepening the model would have been towards specific functionalities and characteristics of GMS. That level of analysis would provide value based information for focusing GMS further development and prioritising the technical requirements. Experiences regarding the gradually growing understanding of feasible modelling scope and details were in line with the notions of iterative and evolutionary nature of system modelling [e.g. 6, p.87].

Importance of visualisation. Pilot Team recognised the importance of visual aspects of the models for guiding and focusing communication and group learning. In the beginning, structural modelling with causal loop diagramming acted also as a conceptual model of important terms and concepts. Because of this, structural diagrams were also called *conceptual* cause and effect models. Pilot Team saw the structural level (see Fig. 3) value creation model with visualised value paths as a potential counterpart for traditional enterprise architecture models. Pilot Team considered the value path concept intuitive which helped in quick understanding of value creation structural model.

VII. Discussion

The research question of this study is *how system dynamics can be used in evaluating IT business value.* The answer was based on seeing the IT impacts on business performance as a combination of structural and dynamic aspects. The structural aspects were examined by asking "How IT impacts value creation, what kind of elements and interconnections are involved?". The dynamic aspects were approached by asking "how much value is realised and when?". SD matched the IT business value evaluation by utilising qualitative modelling methods for structural aspects and quantitative modelling with simulation methods for dynamic aspects. In order to ensure that the IT impacts were evaluated against business value, IT was seen as a part of business system where the system purpose was defined by the earnings logic of the company. The IT business value evaluation was conducted by identifying IT impact chains – value paths – from IT towards goals in the earnings logic level. Qualitative SD modelling was used to identify the structure of value paths and quantitative SD for modelling and simulating value realisation over time within value paths. Together structural and dynamic models formed a value creation model.

Positioning and limitations. SD is both a way of thinking and a concrete method, but not a source of content for value evaluation. SD is neutral for system elements and theories or causal logics forming the interrelationships between the elements, and SD is equally neutral whether the elements of the system model are reflections of hard/tangible or soft/intangible measures of the real world. Based on the above positioning, SD is complementing other research and practice based contributions that provide content level insights into the IT usage types [e.g. 26,9] or different IT benefit and sacrifice categories [e.g. 18,24,44]. This study also has a content dimension by proposing company earnings logic as a starting and anchoring point for identifying the business level content for value creation modelling. However, earnings logic is only one possible business level grounding point and most probably other business model areas (such as resources or co-creation network management) can be more natural starting points for other types of IT systems.

Although this report omits SD working process and facilitation aspects, we see that the efficiency of communication and data collection methods as well as adjustable workshop facilitation activities are critical for successful IT evaluation exercise. Value realisation is dependent on IT usage and the usage is always related to specific company context. The efficiency of identifying and analysing context specific factors in different company settings directly affects the cost-benefit ratio of the value creation modelling.

Based on a single case study, our experiences are limited regarding the balance of qualitative and quantitative modelling. We assume that the explicitness of modelling purpose affects the proper balance and the required modelling iterations. Sterman [6, p.90] emphasises the importance of a reference mode in the very beginning of modelling efforts. The reference mode is a set of graphs or other descriptive data showing the development of a target problem over time. The reference mode is one tangible method for explicitly defining the modelling purpose. Our experiences indicate that several iterations are required until the value creation structures are visible enough for a definition of the reference mode. It is reasonable to assume that the higher level IT (e.g. strategic IT) requires more modelling iterations than the lower level IT (e.g. transactional IT [8]).

Managerial implications. The IT evaluation approach presented in this paper is based on a cross-section of organisational levels from technology to business, thus strengthening the alignment between these two viewpoints. From business performance and investment management points of view, SD based IT evaluation is not replacing the traditional financial measures such as ROI (Return On Investment) or NPV (Net Present Value) analysis. Instead, the presented approach identifies and links the data elements and measures for making the traditional financial measures more representative of the real and dynamic situations. By doing this, SD utilisation helps in opening the 'black box' of IT and enriches the IT business alignment.

From requirements engineering and IT development points of view, the presented approach provides concrete value based insights for focusing and prioritising requirements elicitation and analysis. The value creation model, especially the structural model, provides the development team 'a big picture' where IT can be seen as a part of the business system. Value paths highlight the critical chains that link IT concretely to business value. These critical value paths can be used as one of the drivers when requirements are elicited and prioritised.

Systemic approach encourages the development projects to consider also complementary and transitional factors [17] for value realisation, not merely direct functional and technology oriented requirements. These requirements are no longer solely IT requirements but they are business *system requirements* with responsibilities for value realisation shared within the system. In that case, the entire time horizon of IT lifecycle is considered and the transition from development projects to operations and usage phase is better prepared for the continuous value management.

Prototyping is another application for SD modelling on the development level. Prototyping is a common method for validating requirements and obtaining early feedback for IT development. SD modelling and simulation can be seen as a consequences oriented alternative or complementary method for functionally oriented prototyping.

Research implications. This study argues for holistic IT value evaluation and proposes concrete methods for approaching the IT business value. Utilisation of SD requires integration to organisational knowledge that is, in many cases, diffused within varied groups of stakeholders. The processes and methods for facilitating knowledge and data assimilation into value creation models frame an important topic for further research. This topic can be approached from multiple levels, e.g. 1) how SD is integrated into IT management practices for better business alignment or 2) how SD is integrated into IT development and long term planning practices.

This study argumented the coupling of IT business value evaluation and SD utilisation. However, our literature studies revealed surprisingly few empirical studies about this combination. This observation raises further questions:

- Why coupling of IT business value evaluation and SD seems to be a rare topic in literature? More thorough systematic literature study should be conducted.
- Is SD embedded in the existing practices? When companies perform IT evaluation, how do they implement it? How do the existing practices match the challenges of the IT business value evaluation?

The above mentioned research suggestions form the basis for our further case studies, which have been initiated at the beginning of 2014. Enhancing the dynamic cost and impact factor patterns of EcoPOST framework [43,44] with dynamic value creation factors, present another interesting venue for further research.

VIII. Conclusions

This case study explored IT business value evaluation and utilised system dynamics (SD) for studying IT impacts on different organisational levels. The nature of IT impacts on business value were compiled into 1) structural dimension: **how** IT impacts value creation, and 2) dynamic dimension: **how much** and **when** value is realised**.** SD modelling was used to identify the value paths from IT impacts to business value and for simulating the value realisation over time. SD modelling visualised a map – value creation model – of IT impacts piercing through IT services, processes and usage towards the execution of company earnings logic. The value creation model offered a common language for technology and business parties. Value creation model was seen as a potential tool for promoting value management over the lifecycle of IT: from the value based requirements prioritisation to identification and measuring of enablers and inhibiters for value realisation.

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