A system dynamics model to support strategic decision making on IT Outsourcing: A case study at a state revenue agency in Brazil

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Abstract: **IT capabilities of contracting organizations and outcomes expected by IT outsourcing (ITO) initiatives should be evaluated through every stage of the ITO life cycle for effective ITO management. However, there is a lack of tools and models that consider the dynamic and integrated view of capabilities management, sourcing decision making and benefits management. In this paper we propose and use a model based on the concepts of dynamic capabilities and benefits management for evaluating and managing customers' IT capabilities that need to be applied to outsourcing relationships over time. Preliminary validation of the proposed model is carried out in a case study at a Brazilian state revenue agency where the model was used to support decisions on the distribution of limited human resources between IT capabilities of Contract Monitoring and Service Delivery in ITO scenarios of varying internal-external sourcing partitioning. Results provide evidence that the proposed model can ease and accelerate identification of (more) adequate ITO options.**

Keywords— ***IT Capability Management, IT Outsourcing, System Dynamics Modeling, Benefits Realization Management***

I. INTRODUCTION

Organizations use IT resources and capabilities as assets to create value in the form of goods and services. The portfolio of IT services to be provided and the most rewarding strategy of providing these services in terms of results must be defined in order to create value for the organizations´ business processes. Capabilities represent the ability of an organization to coordinate, manage and deploy resources to produce value [1]. When the organization doesn´t have the resources and internal IT capabilities for the provision of all services comprising the portfolio, it must look for external organizations able to fill the gap [2]. This practice is named *Information Technology Outsourcing* - ITO.

There is a lack of tools and models that help managers to decide which capabilities to develop and / or maintain internal to their organizations, in which quantity or magnitude and how such capabilities behave in a dynamic scenario of constant interaction between client's and vendor's IT teams [3]. Building models that consider the dynamic and integrated view of capabilities management, that support sourcing decision making and benefits management is a still open research topic.

In this work we expand on the ITO decision support model in [3] and apply it to real case IT scenarios.

II. LITERATURE REVIEW AND RELATED WORK

The loss of internal technical skills is an important risk factor for organizations embarking on an ITO initiative [4][5]. However, there is no clarity on the part of managers on how to mitigate this risk in a rational and balanced way, without compromising the potential benefits that outsourcing can provide. The IT capabilities of an organization are not static. They vary over time; they influence and are also influenced by the capabilities of the organizations with which it interacts.

The lack of definitive and consolidated understanding of what constitutes an organization's IT capabilities and how they can be measured brings great possibilities for research. The work presented in [6] identified which IT capabilities are essential for business success, called core capabilities, and which of those have potential for outsourcing.

Software simulation modeling in a software engineering context was presented in [7] to find the best combination of verification and validation techniques with respect to specific time, quality and effort goals and to analyze the effect of the project staffing profile on its performance.

Another important concept is the management of benefits, i.e., the mechanism for measuring the results presented by IT to enhance internal capabilities. Little attention is given to the use of structured approaches and formal verification of benefits brought by IT to the business, especially in investments made on ITO initiatives over time. Exceptions are the works in [8,9]. The study in [8] concluded that benefits management contributes to the success of an ITO relationship. The work in [9] uses an IT Capability Maturity Model Framework (IT-CMF) to enhance the IT capabilities of organizations over time. This paper adds to [8,9].

III. PROBLEM STATEMENT AND OBJECTIVES

The problems of interest here are: a) how to anticipate the re-configuration of internal resources allocation (capabilities) and; b) how to outsource IT capabilities to better meet the planned benefits realization over time.

The main objective of this paper is to provide a model based on the concepts of dynamic capabilities and benefits

978-1-4799-0913-1/14/$31.00 ©2014 IEEE

management for: a) evaluating and managing customers' IT capabilities that need to be applied to outsourcing relationships over time; and, b) supporting identification of (more) adequate ITO options.

IV. THE PROPOSED MODEL

The model was developed using he *Dynamic Synthesis Methodology* (DSM) [10], which combines System Dynamics Simulation Modeling (SDSM) and Case Studies. The modeling approach used here is based on generic process flows, like in [11].

A. Basic Model Entities

Model parameters are divided into four distinct categories: input, calibration, mediator and output. Figure 1 shows an overview of the model. The input parameters represent specific information about the benefits and performance metrics to be achieved, the IT resources available in the organization and the demands for IT functions. Calibration parameters represent specific information about organizations. They are used to adjust the model´s behavior to the reality of organizations or to the scenarios to be simulated. Mediator parameters represent intermediate information obtained from the entries, from calibration and, in situations involving feedback loops, from output parameters. The output parameters are the values calculated based on the dynamic cause-effect relationships between model input, calibration and mediators parameters. The model will produce outputs that reflect the expected performance of IT resources (in terms of cost, quality, resources consumption) as a function of submitted demands.

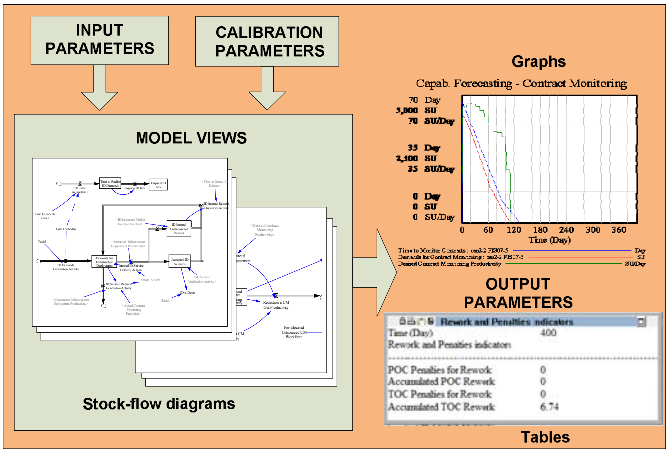

Fig. 1. Model design. Source: Authors

B. Model Views

For clarity, maintainability and reusability, the model was segmented into views, reflecting the organization of policies captured in interviews with model users and stakeholders. The complete list of the model´s views and their descriptions is shown in Table I. Due to space limitations, just two of the views that highlight the core concepts of our approach will be detailed next.

C. The Insourced Capabilities Management View

This view contains the diagrams representing the ITO contracting organization´s side of IT capabilities: *Contract Monitoring Capability* and the *Partially Outsourced Service Delivery Capability* (POC) template.

TABLE I. PROPOSED ITO MODEL´S VIEWS AND THEIR DESCRIPTIONS

View	Content
Financial Management	Models the dynamics of ITO funding.
Demand Management	Models the demand generation and distribution between specific IT capabilities.
Capability Forecasting and Planning	Models how the dynamics of demands drive the capabilities allocation.
Sourcing Management	Models how demands for capabilities are met by own resources and outsourced.
Insourced Capabilities Management	Models the specifics of how the internal corporative resources are allocated/organized in capabilities, delivering productivity to the IT activities.
Outsourced Capabilities Management	Models the specifics of how the IT providers' capabilities are allocated, delivering productivity to the activities.
Contract Monitoring for IT processes	Models the specific behavior of the Contract Monitoring activity influencing the activities executed by IT providers´ capabilities.

Here we assume that a capability is effectively a productivity rate, in Service Units/day, which is calculated based on the productivity of the involved resources (people, material and intangible assets) by the following formula:

*Insourced POC Productivity = Allocated Insourced POC Workforce * Maximum POC Rate per Person per Day * Average POC Skill Level * POC Materials Effectiveness * POC Intangibles Effectiveness*

Maximum POC Rate per Person per Day is a constant used to represent the number of service units that a "optimally skilled" workforce is able to process in a day. The Average *POC Skill Level* parameter takes values between 0 and 1 and represents the average fraction of the optimal skill level presented by the internal staff. Constant *POC Intangibles Effectiveness* and *POC Materials Effectiveness* are just multipliers which represent, respectively, how much material and intangible resources enable staff productivity.

D. The Contract Monitoring for POC View

This view captures the specifics of the demand flow between the contractors IT organization and the ITO provider. This flow, shown in Figure 2, reflects a generic contract monitoring process and the interaction between this capability and IT service delivery capability.

V. SOME RESULTS – A CASE STUDY IN SEFAZ-AL

For the validation efforts, we applied a mix of the frameworks described in [12] and [13], whose steps are: tests of structure, tests of behavior and tests of learning. The organization selected for carrying out the various activities involved in the validation cycle of the model was the Finance and Revenue Agency of Alagoas State, Brazil (SEFAZ-AL). SEFAZ-AL has the largest IT department as well as the most important outsourcing scenario, both in volume and in complexity in Alagoas [14].

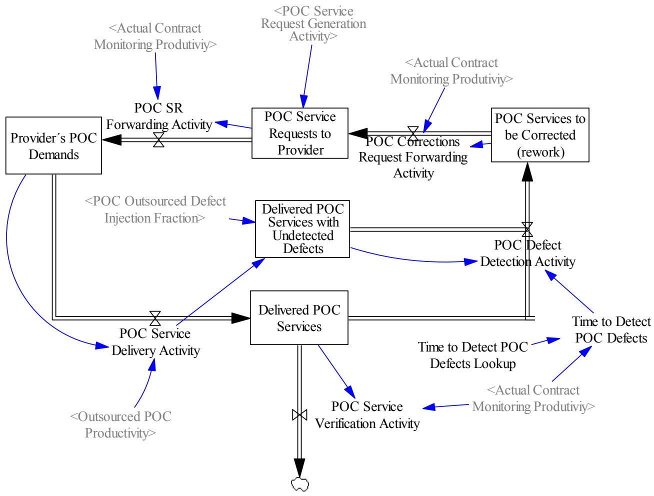

Fig. 2. The interaction between Contract Monitoring and Outsourced Service Delivery (POC) capabilities

Although all stages of the validation process were executed, only the following steps will be detailed: Tests of Behavior - where a baseline was constructed from historical data; and, Tests of Learning - where decision-making scenarios were used to assess the usefulness and compliance with the model objectives.

Basically, three scenarios reflecting different settings in the adoption of ITO were designed: 1) full outsourcing of software development; 2) full insourcing of software development, and; 3) partial outsourcing of software development. Scenario 1 was used to carry out the Tests of Behavior step and scenarios 2 and 3 for the Tests of Learning step.

A. *Case Background*

Having gone through several generations of ITO, SEFAZ-AL has experienced various contract formats and models. The case study conducted here analyses the scope of a contract that has been in operation only a few months back. Its purpose is to provide design and implementation services of new information systems (projects) and maintaining those already in production (continuous services). Previous contracts were not considered because SEFAZ-AL claimed great inconsistency in evaluating their performance metrics thus being unreliable to draw a baseline for the desired behavior.

B. *Performing Tests of Behavior*

The completion of this activity requires a survey of empirical data. We had access to records of service orders (SO) performed during the current contract. We´ve selected 5 SOs sent to the supplier since the inception of the contract in order to build the capacity plan for filling demands based on the contract parameters according to Table II.

Our model uses Service Units (SU) to measure effort. We consider that a Service Unit is equivalent to an hour of effort on information systems development capability.

TABLE II. CAPACITY PLAN FOR SERVICE ORDERS

SO Id	NE (SU)	NCT (Day)	EC (US$)	EWF (Person)
SMT37	392	48	18,879	1.36
NFA15	980	90	47,197	2.59
DEB07	1711	107	82,392	2.66
GRE03	3220	131	155,075	4.10
FIS07	5320	174	256,211	5.10

a. **NE** - Normal Effort; **NCT** - Normal Conclusion Time; **EC** – Estimated Cost; **EWF** - Estimated Workforce

1) *Scenario 1: Full outsourcing of software development*

The implementation of these demands was carried solely by the vendor´s team.

For each SO, effort and deadline were informed. We calibrated the model in order to obtain the simulated deadline and cost as close as possible to those registered in the capacity plan. Table III compares the time and cost initially estimated with the values obtained by simulation.

TABLE III. CAPACITY PLAN X SIMULATION RESULTS - BASELINE FOR THE OUTPUT BEHAVIOR

SO Id	NCT (Day)	NC (US$)	SCT (Day)	SC (US$)
SMT37	48	18,879	48	19,900
NFA15	90	47,197	80	48,100
DEB07	107	82,392	95	83,400
GRE03	131	155,075	117	157,000
FIS07	174	256,211	160	258,000

b. **SCT** – Simulated Conclusion Time; **SC** - Simulated Cost

C. *Performing Tests of Learning*

Starting from the baseline settings, these scenarios allow the user to: 1) disable outsourcing and check if its own pre-allocated resources are sufficient to meet demand on time and cost schedules; 2) enable outsourcing and check if the pre-allocated outsourced resources are sufficient to meet demand in estimated time and cost. This behavior was modeled on the *Partially Outsourced Service Delivery Capability* (POC) template.

1) *Scenario 2: Full insourcing of software development*

After disabling the outsourcing in the model, data from 4 SOs were included in the model according to the capacity plan in Table I. For each SO simulation, the “inventory” of human resources was initialized based on the *Estimated Workforce* column. The internal cost of implementing each SO was calculated based on the salary paid to a customer´s internal staff analyst. The simulation results are shown in Table IV.

TABLE IV. OS EXECUTED BY INTERNAL TEAM

SO Id	Internal Team Size (Person)	Simul. Conclusion time (Day)	Simul. Internal Cost ($)	Cost Reduction (%)
NFA15	2	60	42,700	9.5
GRE03	3	110	93,100	39.96
FIS07	4	138	138,000	46.14

It was observed that the time limits for completion of all SOs were all met, some with slack, even with a smaller amount of allocated human resources than previously expected. The costs were all reduced, some reaching almost half of the originally estimated cost.

2) Scenario 3: Partial outsourcing of software development

Having enabled outsourcing, a sensitivity analysis was conducted to observe how variations in the amount of allocated internal workforce affected cost and conclusion time. The chosen SO (FIS07) was the one with the greatest need for staff, with greater potential for variation in the allocation of this resource. The costs of monitoring contracts were calculated using the *Internal Resources SU Cost* calibration parameter. The simulation results are shown in Table V.

Different configurations for the distribution of human resources between internal capabilities *Service Delivery* and *Contract Monitoring* can be simulated to evaluate which of them improve outcomes. In this case study, the conclusion time was considered the most important metric.

According to the baseline simulation, the following conditions are necessary for the SO FIS07 to be executed within time and cost estimated in the capacity plan: a) in the full outsourcing scenario, 5 people for contract monitoring are required; and b) in the disabled outsourcing scenario, 4 people are needed in the systems development local team. These values generated the following constraints for the sensitivity analysis described below.

- Constraint 1: IWF < 4;
- Constraint 2: IWF + CMW ≤ 5;

TABLE V. SO EXECUTED BY CUSTOMER´S AND VENDOR´S TEAMS

SO Id	**FIS07**						
IWF (Person)	**CT (Day)**	**IPC ($)**	**OPC ($)**	**TPC ($)**	**CMW (Person)**	**CMC ($)**	**TSOC ($)**
1	165	43,900	215,000	258,900	2	70,300	329,200
2	187	91,600	167,000	258,600	3	75,100	333,700
3	194	134,000	127,000	261,000	2	56,900	317,900

c. **IWF** - Insourced POC workforce; **CT** – Conclusion time; **IPC** - Insourced POC Cost; **OPC** - Outsourced POC Cost; **TPC** – Total POC cost; **CMW** – Contract Monitoring workforce; **CMC** – Contract Monitoring cost; **TSOC** – Total SO cost.

For each value of IWF subject to the constraint 1, CMW subject to the constraint 2 was chosen to obtain the lowest CT.

Taking into account the shorter conclusion time, it was found that the best option is to allocate 1 person to the systems development team and 2 people to contract monitoring. It was observed that the differential responsible for the variation in total cost of an SO is the cost generated by the contract monitoring activities, often overlooked by the public administration. This type of expenditure is treated in the ITO literature as “hidden costs” and represents a serious risk factor for the outsourcing process.

VI. FINAL CONSIDERATIONS AND FUTURE WORK

According to SEFAZ-AL users, the usefulness of the model is promising: a) for strategic decision making on sourcing, through the analysis of various what-if scenarios in different phases of the ITO cycle; b) to determine which IT capability and how much outsourcing is needed to better meet the goals set for the ITO initiative; c) to give a better understanding of the influence of ITO contract monitoring capability on service delivery.

Results are preliminary. Although they provide evidence that using the proposed model can ease and accelerate identification of (more) adequate ITO options, further validation effort is needed to increase the model´s credibility.

As future work, we intend to invest in the functional evolution of the model (implementation of benefits management and risk management features) and in learning tests to delimit the model´s applicability coverage.

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