The IT organization modeling and assessment tool: Correlating IT governance maturity with the effect of IT

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Abstract

Does good IT governance improve the effect of IT? This paper presents the IT Organization Modeling and Assessment Tool (ITOMAT) which has been created to overcome operationalization and subjectivity weaknesses in the Control Objectives for Information and related Technology (COBIT) framework. ITOMAT was applied to assess IT governance maturity in four case studies. Simultaneously, external metrics of the effect of IT were collected and correlated to the maturity levels. Based on the correlations, a model linking internal and external measures was created. The model can be used to predict the effect of IT given the maturity levels of IT processes.

Keywords: IT governance, IT organization, effect of IT, COBIT, modeling

1. Introduction

IT governance is an important issue on the agenda of many enterprises. Although there has been a need to provide guidance on the use of IT since the early days of computing, the actual term IT governance did not appear until the nineties, when Loh, Hendersen and Venkatraman used the term to describe the complex array of interfirm relationships involved in obtaining strategic alignment with business and IT [14][5]. Effective IT governance provides mechanisms that enable IS/IT management to develop integrated business and IT plans, allocate responsibilities, and prioritize IT initiatives [13][18][26].

In this paper, we propose a method for IT governance maturity assessment within an enterprise. This kind of assessment is essential for good monitoring, enhancement and management of IT processes and structures. In particular, by using a method for assessing IT governance maturity, it is possible to compare and rationally select between potential future scenarios. For instance, if the decision-making authority for acquisition of commodity software is moved from business unit level to IT operations level, how would that improve the maturity of the affected processes? The possibility to perform trade-off analysis between potential scenarios is one of the most important benefits of having an efficient IT governance assessment method in place. Another benefit is the possibility to benchmark against other organizations. Also, a good IT governance assessment method can provide useful prescriptive results about what can be done to improve the governance of IT within the organization under evaluation.

Currently, a few such methods aiming to support IT governance exist. Weill & Ross have developed an IT governance framework based on just a few questions that can be used to assign responsibilities for high level IT decision making, but their work gives no further guidance on how the IT organization should actually perform their labor [25]. The ISO/IEC 20000 and its preceding IT Infrastructure Library (ITIL) might aid the creation of processes related to delivery and support [9][16]. ITIL also details establishment and maintenance of service level agreements (SLA) and operation level agreements (OLA). However, ITIL gives no support for strategic IT concerns. The most recognized, publicly available, framework for IT governance is COBIT, which is discussed more thoroughly in the third section of this paper [7].

The second section of this paper contains a set of requirements that a method for IT governance maturity assessments should fulfill. Section three presents COBIT and its degree of fulfillment to the requirements. Section four presents the IT Organization Modeling and Assessment Tool (ITOMAT), which intends to overcome some of the problems with COBIT [20]. ITOMAT is also tested against the requirements. Section five suggests external metrics that can be used for black box assessment of IT governance, i.e. the effect of IT governance from the business point of view.

Table 1. Requirements on good IT governance maturity assessments.

ID	Requirement	Domain	Description
RQ1	Consistency with common conceptions	Validity	The method should be based on well-known IT governance sources within academia and practice.
RQ2	Descriptive operationalization	Reliability	The method should support unambiguous and objective depiction of IT governance in an organization by means of a precise representation. If two analysts individually face the task of describing the IT governance in an organization, a descriptively operationalized language would result in both obtaining equal models, while a fuzzier language would not.
RQ3	Normative operationalization	Reliability	The method should support unambiguous and objective analysis of IT governance. It should clearly state how different IT governance concerns affect maturity scores.
RQ4	Support for efficient data collection	Cost	The method should provide an efficient representation of IT governance so that data could be collected with little effort.
RQ5	Support for efficient analysis	Cost	The method should support efficient normative judgments of IT governance so that analysis can be made easily and at a reasonably low cost.

Section six presents results and methodology from an ongoing case study on the correlation between ITOMAT IT governance maturity and external maturity of IT governance. The paper ends with conclusions, acknowledgements and references.

2. Requirements on good IT governance maturity assessments

In measurement theory, the goodness of an assessment is specified in terms of validity and reliability [10]. For practical applications, these benefits need to be traded against the cost of performing the measurement. The following subsections present a set of requirements within the domains of validity, reliability and cost, which are also summarized in Table 1. A more elaborate description of the requirements can be found in [20].

2.1. Validity

Validity is often defined as the extent to which a measure accurately reflects the concept that it is intended to measure. In the case of a badly calibrated method for IT governance maturity assessment, perhaps the general goodness of business processes or the administrative concerns of IT operations is actually evaluated. The method should therefore rely on existing state of practice definitions of the subject.

2.2. Reliability

Reliability may be defined as the extent to which a measure yields consistent, stable, and uniform results over repeated measurements of the same unit. Repeated assessments, or assessments made by different analysts, should lead to the same results each time. Therefore, the maturity assessment method must be succinctly operationalized, which means that the method must be unambiguous with respect to two important aspects. Firstly, the method should be operationalized with respect to the data that needs to be collected. Secondly, the method should be operationalized with respect to aggregation of data into assessment results, which are typically presented in terms of a maturity level.

2.3. Cost

Upon applying assessment methods in the real world, it is of utmost importance that assessment costs are kept at a minimum. The assessment costs can be divided in two different parts. Firstly, there is the cost of collecting data such as performing interviews or studying enterprise documentation. Secondly, there is the cost of performing the analysis by transforming the collected data into truly valuable support for decision making. At best, it should be possible to employ the assessment method without the help of knowledgeable yet expensive consultants.

3. COBIT's IT governance maturity assessment method

Control OBjectives for Information and related Technology, COBIT, is a well-known framework for IT governance improvement, risk mitigation, IT value delivery and strategic alignment maturity assessments [2][3][4][6][17][24]. The framework was first issued by the IT Governance Institute, ITGI, and Information Systems Audit and Control Association, ISACA, in 1998 and has been constantly evolving ever since [7][8]. It describes the IT organization by means of 34 processes, within four domains: Plan & Organize, Acquire & Implement, Deliver & Support, and Monitor & Evaluate. Each process contains several activities and a set of detailed control objectives, i.e. statements of the desired results to be achieved

Table 2 COBIT's fulfillment to requirements on good IT governance maturity assessments, cf [8].

ID	Requirement	COBIT fulfillment	Comment/Evidence
RQ1	Consistency with common conceptions	Yes	+ COBIT is a de facto standard in the field, c.f. [2][3][4][6][17][19][21][22][24].
RQ2	Descriptive operationalization	Partly	+ COBIT lists all the processes, activities, documents, etc. needed to correctly represent IT governance concerns. - COBIT hosts a sometimes incongruent notion of activities and resembling control objectives, c.f. [8], processes PO1, PO2, AI4, DS1, and DS2. + COBIT provides a scale on which to measure: A. "Awareness & Communication", B. "Policies, Plans and Procedures", C. "Tools & Automation", D. "Skills & Expertise", E. "Responsibility & Accountability", and F. "Goals and Measurement", c.f. [8] pp. 21. - COBIT provides no guidance regarding what information is needed for assessment of A, C, and D, according to above, c.f. [8] pp. 21. - COBIT does not separate (descriptive) representation from (normative) assessment. - COBIT does not elaborate on exactly what data is needed collect in order to assess each process.
RQ3	Normative operationalization	No	+ COBIT provides scales for process level maturity assessment. - COBIT describes what can be measured, e.g. [8] pp 107, but provides no information regarding the connection between this process description and the attribute maturity, [8] pp. 21. - COBIT does not describe aggregation from attribute maturity to process maturity models, e.g. [8] pp. 108. - COBIT does not elaborate on how process maturities may be aggregated to a mean maturity for the 34 processes.
RQ4	Support for efficient data collection	No	- Data collection and analysis is not clearly separated in COBIT and must both be carried out by experienced analysts.
RQ5	Support for efficient analysis	No	- COBIT does not provide any support for efficient analysis.

by implementing control procedures for the processes. Metrics such as key performance indicators (KPI), key goal indicators (KGI), and critical success factors (CSF), are suggested in order to monitor the general goodness of each process. Lists of inputs and outputs for each process are also presented. Further, each process is connected to a capability maturity model (CMM). The latest versions of COBIT also contain RACI matrices, which suggest stakeholders to be Responsible, Accountable, Consulted, and Informed regarding the activities according to above. Table 2 considers COBIT's degree of fulfillment to the requirements on IT governance maturity assessments.

4. ITOMAT - the IT organization modeling and assessment tool

As demonstrated in the previous section, COBIT did not fulfill all requirements for a good IT governance maturity assessment method. In particular, COBIT performs weakly with respect to requirements RQ3 to RQ5. This paper proposes a method for model-based maturity assessment of IT governance which is based on the existing COBIT framework. It leverages the benefits of COBIT and mitigates some of the weaknesses. The proposed method can thus be viewed as an extension of COBIT and will hereafter be named the IT Organization Modeling and Assessment Tool, ITOMAT. The method contains two parts [20]: The *modeling language* provides a descriptive representation of how IT is governed within the assessed company. The *analysis framework* provides support for the evaluation of whether the given IT governance structure is good or bad.

4.1. The ITOMAT modeling language

As mentioned previously, it was decided to base the IT governance modeling language on the existing COBIT framework. The structure of COBIT allowed identification of entities and relations, as described in the following subsection.

4.1.1. Entities

The notion of *processes* to describe the IT organization is commonly used and was inherited directly from COBIT. The content of 34 processes relevant for management, control and operation of IT is detailed. However, since not two organizations are alike on process level, the notion of a general process serving as a container of elements with finer granularity, i.e. activities, was chosen. COBIT distinguishes between *activities* and detailed control objectives. Even though there is a conspicuous

overlap between the detailed control objectives and activities, they are not completely alike. It the belief of the authors of this paper that, given COBIT's origin of being a tool for IT auditors, the detailed control objectives are certainly convenient for auditors performing a check-list style revision of a company's IT. The activities are however better aligned with the RACI matrices and they were therefore selected for the modeling language. Each process contains one or more activities, which represent the actual content of the work performed within the IT organization.

It is frequently stated in COBIT that certain *documents* should be produced to assure that activities are correctly executed. The documents are represented as process inputs and outputs in COBIT, and modeled in the same way in ITOMAT.

COBIT also lists a vast number of metrics that can be used to monitor the progress of each process and its maturity. Those are represented as *metrics* in ITOMAT's modeling language.

Moreover, COBIT contains an equally large amount of goals for activities, processes and IT in general. By now, these are excluded from the modeling language, as we did not want to assess the existence of goals within an organization, but rather desired to focus on the current achievements. An IT organization's fulfillment to external metrics is considered in Section 5.

A very important aspect of IT governance concerns the locus of IT decision making. No less than 19 different stakeholders for IT governance are presented in COBIT. Since few IT organizations employ all of them, ITOMAT's *role* entity features a more coarse representation featuring just five stakeholder groups. ITOMAT's roles has inherited the distinction between executives, business and IT from Weill & Ross [25] but has added two more roles from COBIT in order to represent IT operations and audit, c.f. Table 3.

4.1.2. Relations

The RACI matrices provided by COBIT states that each IT related activity may be associated with a role, so that the role is *responsible, accountable, consulted* or *informed* with respect to the activity. These relations were incorporated in the modeling language.

However, in ITOMAT, the relations connect roles with processes instead of activities, as stated in COBIT. This decision was made to minimize the number of relations to be modeled. Where COBIT originally states that four

Table 3. Roles in ITOMAT and COBIT.

ITOMAT role	COBIT role
Executives	The Board
	Chief Executive Officer
	Chief Financial Officer
Business	Business Executive
	Business Process Owner
	Business Senior Management
IT management	Chief Information Officer
	Chief Architect
	Head Development
	Program Management Officer
IT operations	Head Operations
	Deployment Team
	Head IT Administration
	Training Department
	Service Managers
	Service Desk/Incident Manager
	Configuration Manager
	Problem Manager
Compliance, audit, risk and security	Compliance, audit, risk and security personnel

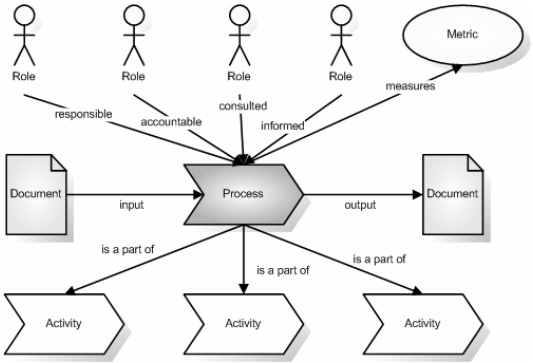

Figure 1. Example of IT governance model, based on the ITOMAT modeling language.

relations should be mapped for 19 roles and some 200 activities, ITOMAT suggests mapping the same relations for just five roles and 34 processes. As mentioned previously, the interfaces between COBIT's processes contain mainly documents. In order to model this, relations to denote *inputs* and *outputs* were created. A *measures* relation connects a metric with a process. Finally, a *is a part of* relation denotes that a process contains one or more activities. Figure 1 shows how responsibilities, metrics, documents and processes can be modeled.

4.2. The ITOMAT analysis framework

In the previous subsection, a language for modeling the parts of an IT organization relevant from an IT governance perspective is presented. By using such, it is possible to create a model of any organization's current or future IT governance structure. In the following

subsections, a framework for assessing the maturity of such a model is presented. A standardized set of internal metrics is presented in subsection 4.2.1 and a procedure for aggregation of separate metrics into a total maturity score is presented in subsection 4.2.2. Table 4 lists the internal metrics that are taken into account, and presents how maturity levels are assigned.

4.2.1. Internal metrics

COBIT provides a plethora of performance indicators, responsibility assignment suggestions, activities and goals that can be monitored in order to obtain good IT governance. COBIT also contains process level maturity models. However, the maturity models presented in COBIT contain only a few lines of plain text describing the characteristics for each maturity level, and the framework doesn't detail the connection between the metrics and maturity levels. In other words, it is not clarified how monitoring of a single metric would affect the maturity of an entire process. As mentioned previously, one of the purposes with ITOMAT is to overcome this problem.

By studying the process level maturity models carefully, the authors of this paper identified four generic metrics. These are *activity execution*, *assigned responsibilities*, *documents in place*, and *metrics monitoring*, c.f. Table 4. These are called *internal metrics*, *IM,* as they assess the performance of the IT organization as a white box, from looking at what is performed rather than what is delivered.

Given the value of an internal metric, a maturity level has to be assigned. Slight modifications of the maturity models presented in COBIT had to be made to minimize the subjectivity of the assessment.

The maturity model in COBIT defined for processes was in ITOMAT generalized to allow for maturity assessments at activity level, i.e. the *activity execution* metric.

The maturity levels for the *assigned responsibilities* metric are assigned in terms of the number of RACI relationships specified for each process and role, and how well these are aligned to the relationships stated in COBIT.

For *documents in place* and *metrics monitoring*, the maturity model is based on a linear assumption of COBIT's focus on quantity in documentation and monitoring of metrics. This gives ITOMAT a clear advantage, allowing an organization to be modeled using a maturity model with well defined levels linked to the outcome of specific metrics.

4.2.2. Aggregation of internal metrics

Since COBIT does not elaborate on how different internal metrics, *IM,* should be aggregated to maturity scores, *MI*, on process or enterprise level, a series of assumptions is made in ITOMAT to overcome this problem. For each process, the metrics are aggregated into maturity scores. The maturity score of a process, $MI_{Process}$, is naïvely calculated as the average of its underlying activities, the documents in place, monitoring of metrics and the assigned responsibilities. The metrics can also be assigned weights. In the formula below, i is an activity index and the sum of all weights $W_{Activity}$ should be equal to one.

Table 4. ITOMAT's internal metrics, *IM*, for assessment of IT governance maturity, *MI*.

MI: Internal maturity level	IM: Activity execution	IM: Assigned responsibilities	IM: Documents in place	IM: Metrics monitoring
0	No awareness of the importance of issues related to the activity. No monitoring is performed. No documentation exists. No activity improvement actions take place.	No relations exist	0 %	0 %
1	Some awareness of the importance of issues related to the activity. No monitoring is performed. No documentation exists. No activity improvement actions take place.	R or A relations exist	20 %	20 %
2	Individuals have knowledge about issues related to the activity and take actions accordingly. No monitoring is performed. No documentation exists. No activity improvement actions take place.	R or A relations exist. At least 40 % or relations in line with COBIT.	40 %	40 %
3	Affected personnel are trained in the means and goals of the activity. No monitoring is performed. Documentation is present. No activity improvement actions take place.	R or A relations exist. At least 60 % of relations in line with COBIT.	60 %	60 %
4	Affected personnel are trained in the means and goals of the activity. Monitoring is performed. Documentation is present. The activity is under constant improvement. Automated tools are employed in a limited and fragmented way	R or A relations exist. At least 80 % of relations in line with COBIT.	80 %	80 %
5	Affected personnel are trained in the means and goals of the activity. Monitoring is performed. Documentation is present. Automated tools are employed in an integrated way, to improve quality and effectiveness of the activity	R or A relations exist. 100 % of relations in line with COBIT.	100 %	100 %

$$MI_{process} = W_{activity} \sum_{i=1}^{I} \frac{MI_{activity,i}}{I} + W_{documents} MI_{documents} + W_{metrics} MI_{metrics} + W_{relations} MI_{relations}$$

The naïve assumption is that all metrics have equal weights, e.g. W = 1/4 for each. The enterprise level maturity could be computed as the average maturity of all underlying processes. Also at this level, weights could be assigned to each process.

$$MI_{enterprise} = \sum_{j=1}^{J} \frac{W_{process,j} MI_{process,j}}{J}$$

However, there are other ways to aggregate maturity from different processes into a single maturity score. All processes influence the total maturity score differently, and what really matters is not the internal maturity of the IT organization, but rather its fulfillment to business requirements. Correlating the maturity of IT processes according to ITOMAT, with assessments of the business' perception of IT quality, would provide valuable input to set such weights, *W*. This correlation could be made by conducting case studies, and such will be described in section 5. Before that, we will however elaborate on whether or not ITOMAT complies with the requirements stated in Section 2, cf Table 5. Please also refer to Table 2 for a comparison of COBIT and ITOMAT.

5. Internal and external IT governance maturity

As discussed previously, COBIT and ITOMAT both aim at assessing the maturity, *MI*, for IT governance of an organization. This is done by studying internal metrics, *IM*, of the IT organization, i.e. the activities, metrics, documents, and responsibility assignments. But the overall goal for IT governance, and IT in general, is to support the business in reaching its goals such as minimize costs, become a more flexible actor on the market, proactively provide new services, etc. Whether or not this is accomplished is not evaluated in COBIT's and ITOMAT's maturity models. Both focus on the internal quality of IT governance. In order to determine whether an IT organization is truly good, one has also to study it from the outside by using *external metrics*, *EM*. The external quality of an IT organization could be measured in two different ways. One could either use *financial metrics*, such as turnover, profit, number of employees, total cost of IT, number of incidents, etc.

However, financial metrics tend to be quite abstract. Many things other than the quality of the IT organization might influence them. Another option would be to study the effect of IT by using *percepted IT quality metrics*. Such information could be collected by surveying business people on the quality of the services that the IT organization delivers, such as service level compliance, or if the IT organization is flexible once the business desires to change strategy. The disadvantage of using percepted IT quality metrics is the increased subjectivity - the answers might depend on who the question is asked to. There are several criteria for evaluation of percepted IT quality, including the following:

- Literature support for use of metric exists
- The metric can be operationalized
- Possible to assess metric on objective scale
- Low cost for obtaining trustworthy answer
- The metric is somehow affected by IT

Table 5. ITOMAT's fulfillment to requirements on IT governance maturity assessments. See also Table 2.

ID	Requirement	ITOMAT fulfillment	Comment/Evidence
RQ1	Consistency with common conceptions	Yes	+ ITOMAT is solidly based on COBIT.
RQ2	Descriptive operationalization	Yes	+ ITOMAT inherits all concepts from COBIT. + Objective assessment is improved by detailing precisely what entities and relations that should be modeled.
RQ3	Normative operationalization	Yes	+ ITOMAT provides a fully transparent and formalized analysis framework that enables aggregation of single metrics to comprehensive maturity scores on process and enterprise level.
RQ4	Support for efficient data collection	Yes	+ ITOMAT provides a modeling language that enables modeling to be separated from analysis. The modeling can be performed by people with little knowledge of the normative aspects of IT governance assessments.
RQ5	Support for efficient analysis	Yes	+ ITOMAT provides an automated analysis framework that can be applied without assistance of an experienced (expensive) consultant.

Table 6. External metrics, *EM*, for assessment of IT governance maturity.

	How important are the following outcomes of your IT governance, on a scale from 1 (not important) to 5 (very important)?
B1a	Cost effective use of IT
B1b	Effective use of IT for growth
B1c	Effective use of IT for asset utilization
B1d	Effective use of IT for business flexibility
	What is the influence of IT governance in your business on the following measures of success, on a scale from 1 (not successful) to 5 (very successful)?
B2a	Cost effective use of IT
B2b	Effective use of IT for growth
B2c	Effective use of IT for asset utilization
B2d	Effective use of IT for business flexibility
B3	**Is IT well aligned with the business? I.e, is there a close match between IT's offered services, and the actual business requirements on IT services?**
	No, IT is not at all aligned with the business requirements
	IT is to a small extent aligned with the business requirements
	IT is to a large extent aligned with the business requirements
	IT is completely aligned with the business requirements
B4	**Do up-to-date descriptions of IT's offered services and service levels exist?**
	No, such descriptions do not exist or are not up-to-date
	Up-to-date descriptions exist for a few IT services
	Up-to-date descriptions exist for most IT services
	Up-to-date descriptions exist for all IT services
B5	**Does IT comply with agreed-upon service levels? If such do not exist, does IT comply with requirements implicitly stated by the business?**
	No, not at all
	Yes, but just for a few of the offered services
	Yes, for most of the offered services
	Yes, for all of the offered services
B6	
	To what extent have critical business operations been affected by IT service interrupts over the past 12 months?
	Weekly
	Monthly
	Yearly
	Never
B7	
	How many percent of all IT projects are delivered on time, on budget, and according to business quality standards?
	0-25%
	25-50%
	50-75%
	75-100%
B8	**Upon installation or upgrade of hardware and software, to what extent does the IT department get it right the first**
	0-25%
	25-50%
	50-75%
	75-100%

Several metrics were evaluated according to these criteria, including a list of IT goals presented in COBIT (which however not is included in COBIT's maturity models) and questions from Weill & Ross' large scale IT governance survey on 250 organizations worldwide [7][25]. A survey form with 14 percepted IT quality metrics was created, cf. Table 6. An assessment framework was created and each metric was normalized.

The average of the external metrics correspond to an external maturity score ME ranging from 0 to 5, just as in the case of ITOMAT's internal maturity score MI, c.f. Section 4. ME is considered a function ME=f(EM). Moreover, a set of general financial metrics was identified. In the next section, it is described how both internal and external metrics were collected in a case study and how correlation between them can be calculated.

6. ITOMAT case studies

A series of case studies has been initiated. The overall goal of the case studies is to find internal metrics for IT governance that highly correlates with external metrics of the IT governance. Once it is established which IT processes that are indeed correlated with the perceived quality of IT, a more efficient assessment of IT governance maturity can be made. By August 2007, four case studies have been carried out in order to calibrate the method for data collection and correlation analysis and ten more studies are initiated. The following subsection elaborates on the case study methodology and the results from each study. In the subsequent subsection, a linear regression between MI and ME is presented, and Bayesian network [11][15] is outlined.

6.1. Collection of internal and external metrics

For each of the four organizations under evaluation, between six and 30 interviews were held with IT stakeholders such as the CIO, IT architects IT operations personnel, and risk managers. The purpose was to model the IT organization according to ITOMAT. All 34 IT processes according to COBIT and ITOMAT were assessed. Models of the IT organizations were created in the METIS enterprise architecture tool [23], by using an ITOMAT metamodel according to Section 4.1 especially designed for the purpose. The external metrics were collected by sending out a survey to business process owners or people with similar responsibilities. The remainder of this subsection gives a brief description of the companies under evaluation and presents the obtained results. Some numerical results for the four case studies are presented in Table 7.

Company A is a medium-sized company that produces, distributes, and sells energy to 57.000 private and corporate customers in Sweden. The annual turnover of the electric utility is about EUR 120 Million. A small department with six full-time employees has the overall responsibility for enterprise IT, but operation and support is partly outsourced to an external service provider. Six two-hour interviews were made.

Company B is a small, Sweden-based biotech company. Its IT organization consists of 16 persons centrally located, and a dozen more distributed over several countries. US Food & Drug Administration's traceability regulations apply and highly affect the work of the IT organization, which is clearly document driven. 20 interviews, one hour each, were made.

Company C is a multinational investment bank. The study was delimited to the markets division, located in the UK. The IT department consists of approximately 30 employees, but many more are involved in near-IT processes regarding risk management and compliance. IT is a highly important asset and business enabler for Company C. Cost is not really an issue when striving to ensure excellent IT support for business processes. 30 interviews of thirty minutes each were made.

Company D is the Scandinavian branch of an international mobile telephone service provider. The IT department consists of approximately 100 employees, responsible for IT service delivery to 1200 employees and thousands of cell phone users. The organization still remains in the spirit of a startup company, but formal back office processes for IT are increasingly implemented. Twelve interviews of one hour each were made.

Table 7. Results for internal maturity of process PO1, MI_{PO1}, internal maturity of enterprise, $MI_{Enterprise}$, and external maturity, *ME*, based on four case studies.

Case study	MI_{PO1} (ITOMAT)	$MI_{Enterprise}$ (ITOMAT)	ME (Survey)
Company A	1.0	1.5	1.0
Company B	2.2	2.0	1.6
Company C	2.4	3.4	4.0
Company D	2.2	2.0	1.4

6.2. Creating a model for IT governance maturity prediction

The processes were assessed by studying four internal metrics according to Section 4.1: *metrics monitoring*, *activity execution*, *documents in place* and *assigned responsibilities*. The models were then subjected to the analysis framework presented in Section 4.2, and the internal maturity, *MI*, was calculated for all processes. A Pearson correlation [1] was performed to analyze the relation between *MI*s of the four internal metrics. 136 processes served as input data for three *MI*s, but since *assigned responsibilities* has not yet been assessed for Company A, only 102 processes could be used for correlation analyses. Statistically significant, positive correlations were found in most cases according to Table 8. This means that if an organization displays a high maturity $MI_{Documents}$ regarding e.g. the *documents in place* metric for a process, it is also highly certain that upon assessing the *metrics monitoring* for the same process, $MI_{Metrics}$ would also be high.

Table 8. Pearson correlation coefficients [1] between internal metrics, based on 102/136 IT processes from four case studies. 1 means perfect positive correlation, 0 means no correlation.

Pearson Correlation		Metrics monitoring	Activity execution	Documents in place	Assigned responsibilities
Metrics monitoring	Correlation	1	0.30(*)	0.54(*)	0.53(*)
	Sig. (2-tailed)		0.00	0.00	0.00
	N	136	136	136	102
Activity execution	Correlation	0.30(*)	1	0.41(*)	0.16
	Sig. (2-tailed)	0.00		0.00	0.10
	N	136	136	136	102
Documents in place	Correlation	0.55(*)	0.41(*)	1	0.42(*)
	Sig. (2-tailed)	0.00	0.00		0.00
	N	136	136	136	102
Assigned responsibilities	Correlation	0.54(*)	0.16	0.42(*)	1
	Sig. (2-tailed)	0.00	0.109	0.00	
	N	102	102	102	102

*. Correlation is significant at the 0.01 level (2-tailed).

But does good internal IT governance maturity affect the quality of IT delivered to the business? The authors hypothesize that *ME*=f(*MI*) and *MIs* for the 34 processes, according to the first formula in Section 4.2.2, were correlated to *ME*. As an example, the internal maturity for process PO1: *Define a strategic IT plan* of companies [A; B; C; D] were MI_{PO1} = [1.0; 2.2; 2.4; 2.2;], cf. Table 7. The corresponding external maturities were *ME* = [1.0; 1.6; 4.0; 1.4]. This corresponds to a Pearson correlation [1] of magnitude 0.6 with a significance of 0.4, i.e., the higher the maturity MI_{PO1}, the higher the value of the average external metric *ME* (August 2007, four case studies).

The Pearson correlation coefficient does however not depict how *MI* and *ME* are interlinked; it just stipulates the strength of the relation between them. One approach to approximate this function is linear regression [1]. This includes finding a linear equation so that:

$$ME \approx ME_{Approx} = f(MI); ME_{Approx} = k * MI + m$$

By applying linear regression to the example above, the relation between MI_{PO1} and ME_{Approx} could then be written as: $ME_{Approx} = 1.2 * MI_{PO1} - 0.4$.

Such equations were created for the relation between *MI* of all 34 processes in ITOMAT, and

ME. The remainder of this subsection will outline how linear regressions for *ME* and *MI* can be used together with Bayesian networks to make statements on which IT processes really affect IT quality from a business point of view.

Clearly, in order to make correct statements, an infinite amount of data would be needed. Furthermore, due to the variety of the datasets, i.e. the differences between organizations under evaluation, a linear regression may never perfectly predict the maturity of *ME* given *MI*.

Apart from having a model that returns perfectly certain results, the second best choice would be to account for the certainty of the predictions. In order to coarsely estimate the certainty of the linear regression, the error of the approximations was calculated. Given the value of the assessed internal maturities, e.g. MI_{PO}, the standard deviation between the differences in *ME* and ME_{Approx} was calculated. The result was 34 models of the relation between a single *MI*, and a range of possible values for the approximation ME_{Approx}.

A more general model that accounts for the combination of all *MI* and ME_{Approx} was created by using a Bayesian network [11][15]. Such can be described as a probabilistic graphical model that represents a set of variables and their probabilistic dependencies. A Bayesian network consists of several nodes, each defined with a Conditional Probability Matrix (CPM). Such matrices define the state of a node given the state of the nodes it is influenced by. A Bayesian network was created with one node for each process' *MI*, and one node representing *ME*. The CPMs were populated with certainties from the linear regressions with a range of values for ME_{Approx}. This was done using the GeNIe tool [10] which allows simulation of ME_{Approx}, given that just a few of the internal metrics *MI* are known.

Figure 2 shows an example screenshot from GeNIe. Based on the four case studies, ME_{Approx} would correspond to maturity level 1 with a certainty of 50 %, given that MI_{PO1}=2, MI_{PO3}=2, MI_{P41}=1, MI_{PO7}=0, and the remaining *MIs* unknown. All in all, it would be possible to make a coarse prediction of the effect of IT by just assessing the internal quality of four IT processes. Since only four case studies have been made so far, these approximations are not yet significant and the methodology has just been outlined in this paper. The Bayesian network will however become truly useful as soon as more data is collected. This will be accomplished once a large series of ongoing ITOMAT case studies are finished by fall 2007.

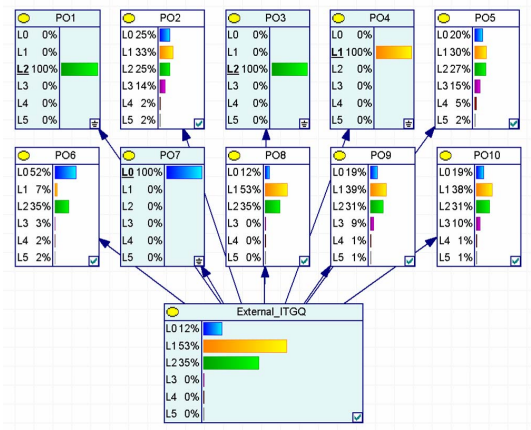

Figure 2. Excerpt from Bayesian network with internal and external maturities that can be used to predict IT governance maturity and effect of IT.

7. Conclusions

This paper has presented the IT Organization Modeling and Assessment Tool, designed to overcome the problems of validity, reliability and cost that are commonly associated with such methods today. One of the major benefits is that the person performing the assessment doesn't necessarily have to be an IT governance expert, since the analysis part is performed automatically. Further, ITOMAT has been applied in four thorough case studies in order to collect internal metrics for IT governance maturity. External metrics on IT governance maturity were also collected.

A Bayesian network representing the relation between internal maturity of IT processes, and the effect of IT is outlined. Such network can be used either to define which IT processes really affect the quality of IT, as seen from the business point of view, or to make quick assessments of IT governance maturity by assessing just a few processes. As more data is collected, the network will become truly useful.

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