A Survey on Economic-driven Evaluations of Information Technology

Bela Mutschler, Novica Zarvić[*]*, Manfred Reichert*
University of Twente, Information Systems Group
{b.b.mutschler,n.zarvic,m.u.reichert}@utwente.nl

Abstract

The economic-driven evaluation of information technology (IT) has become an important instrument in the management of IT projects. Numerous approaches have been developed to quantify the costs of an IT investment and its assumed profit, to evaluate its impact on business process performance, and to analyze the role of IT regarding the achievement of enterprise objectives. This paper discusses approaches for evaluating IT from an economic-driven perspective. Our comparison is based on a framework distinguishing between classification criteria and evaluation criteria. The former allow for the categorization of evaluation approaches based on their similarities and differences. The latter, by contrast, represent attributes that allow to evaluate the discussed approaches. Finally, we give an example of a typical economic-driven IT evaluation.

Keywords: IT Evaluation, Costs, Benefits, Strategy.

1 Introduction

Providing effective IT support has become crucial for enterprises to stay competitive in their market [4]. However, it remains a complex task for them to select the ”right” IT investment at the ”right” time, i.e., to select the best possible IT solution for a given context [24].

Generally, the adoption of *information technology* (IT) can be described by means of an *S curve* (cf. Fig. 1A) [19, 20, 74]. When new IT emerges, it is unproven, expensive, and difficult to use. Standards have not been established, and best practices still have to emerge. At this point, only ”first movers” start projects based on the emerging IT. They assume that the high costs and risks for being an innovator will be later compensated by gaining competitive advantage [18].

Picking up an emerging IT later, by contrast, allows to wait until it becomes more mature and standardized, resulting in lower introduction costs and risks. However, once the value of IT has become clear, both vendors and users rush to invest in it. Consequently, technical standards emerge and license costs decrease. Soon the IT is widely spread, with only few enterprises having not made respective investment decisions. The S curve is then complete.

Factors that typically push a new IT up the S curve include standardization, price deflation, best practice diffusion, and consolidation of the vendor base. All these factors also erode the ability of IT as a mean for differentiation and competitive advantage. In fact, when dissemination of IT increases, its strategic potential shrinks at the same time. Finally, once the IT has become part of the general infrastructure, it is typically difficult to achieve further strategic benefits (though rapid technological innovation often continues). This can be illustrated by a *Z curve* (cf. Fig. 1B).

Considering the different curves of IT adoption, decisions about IT investments (and the appropriate moment of their introduction) constitute a difficult task to accomplish [17, 29] (cf. Fig. 1C). Respective decisions are influenced by numerous factors [42, 51, 53]. Hence, policy makers often demand for a business case [66] summarizing the key parameters of an IT investment. Thereby, different evaluation dimensions are typically taken into account [45]. As examples consider the costs of an investment, its assumed profit, its impact on work performance, business process performance, and the achievement of enterprise objectives.

In order to cope with different evaluation goals, numerous evaluation approaches have been introduced [61, 70, 71]. This survey gives an overview of existing evaluation approaches and discusses their suitability to deal with the complex economics of IT investments.

The remainder of this paper is organized as follows. Section 2 introduces basic terminology related to IT evaluation. Section 3 introduces our framework for classifying and evaluating considered approaches. Section 4 deals with approaches for conducting evaluations from a financial viewpoint. Section 5 discusses methods for evaluating the impact of IT on business process and work performance. Finally, Section 6 describes approaches for analyzing the impact of IT on enterprise objectives. Section 7 sums up and gives an overview of the discussed evaluation approaches.

[*]supported by the Netherlands Organisation for Scientific Research (NWO), project 638.003.407, Value-based Business-IT Alignment (VITAL)

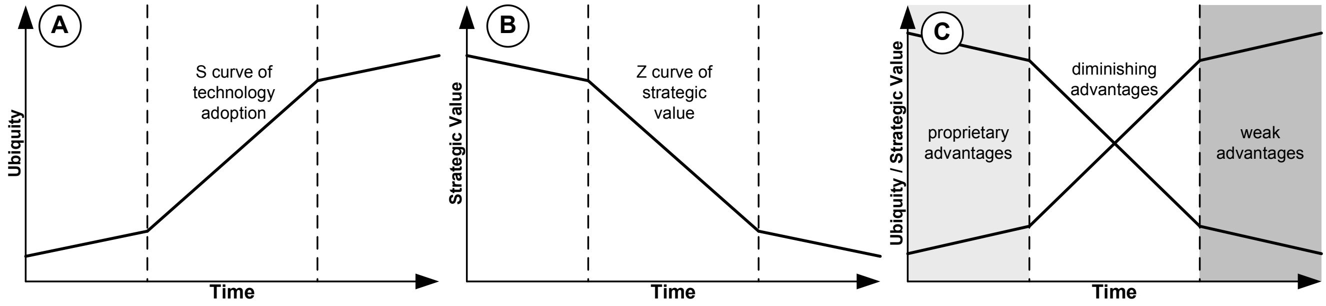

Figure 1. The Curves of Technology Adoption.

Section 8 presents approaches that address value considerations without being conceived as evaluation approaches. Section 9 gives an example showing how selected evaluation approaches can be used for evaluating IT. Section 10 concludes the survey with a summary.

2 Basic Terminology

Economic-driven IT evaluation typically focuses on the systematic analysis of related *costs*, *benefits*, and *risks* [55] (though other aspects can be addressed as well). These terms are characterized in the following.

2.1 Costs

Generally, *costs* can be defined as the *total expenses for goods or services including money, time and labor*. Literature distinguishes between different *cost types* [38]:

- ***Acquisition Costs***: Refer to all costs which occur prior to an investment. This includes costs for purchasing an asset (e.g., an information system) as well as installation costs.
- ***Historical Costs***: Describe the total amount of money spent for an investment at purchase time or payment. Historical costs are often listed in bookkeeping records. They are also denoted as *accounting costs*.
- ***Opportunity Costs***: Denote the difference between the yield an investment earns and the yield which would have been earned if the costs for the investment had been placed into an alternative investment generating the highest yield available.
- ***Internal and External Costs***: External costs occur outside an organization and can be controlled by contracts and budgets. Internal cost, by contrast, occur within an organization (e.g., related to a specific project).
- ***Direct and Indirect Costs***: Direct costs are associated with a particular cost factor, i.e., they can be budgeted. Indirect costs, by contrast, cannot be budgeted, i.e., they cannot be represented with an explicit cost factor.

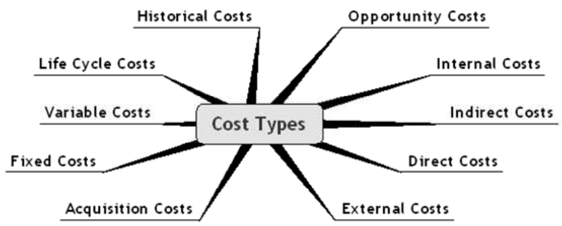

Figure 2. Different Types of Costs.

- ***Fixed and Variable Costs***: Fixed costs do not vary, i.e., they do not alter during a given time-period. Variable costs, by contrast, may change [64].
- ***Life Cycle Cost***: Refer to the costs of an investment over its entire life cycle. This includes costs for planning, research, development, production, maintenance, disposal, as well as cost of spares and repair times.

Considering this variety it seems hardly possible to introduce a standard meaning for the term ”costs”. Instead, every evaluation approach addressing costs has to carefully describe the assumed semantics in the given context.

2.2 Benefits

In economic-driven IT evaluations, costs are typically justified by expected benefits which are assumed to be gained through an IT investment. Generally, ”benefit” is a term used to indicate an advantage, profit, or gain attained by an individual or organization. Basically, two categories of benefits are distinguished [2, 35, 36]:

- ***Tangible Benefits***: Tangible benefits are measurable and quantifiable [76]. Typically, monetary value can be assigned to tangible benefits. Regarding their quantification, one distinguishes between (i) *increased revenues* (i.e., resulting from increased revenues) and (ii) *decreased costs* (i.e., equating to cost savings).

- ***Intangible Benefits***: Unlike tangible benefits, intangible benefits are typically not quantifiable. Instead, qualitative value (derived from subjective measures) is assigned to them [49]. As a typical example consider the impact of an investment on customer or employee satisfaction. Due to their complex quantification, intangible benefits are often not considered in a business case as they introduce a too great margin of error in economic calculations.

This categorization can be also observed when considering existing economic-driven IT evaluation approaches. While some evaluation approaches strictly focus on the quantification of tangible benefits [17, 70, 71], others consider intangible economic effects [36, 44, 59, 62].

2.3 Risks

Risk is the potential (positive or negative) impact of an investment that may arise from some present situation or some future event. It is often used synonymously with "probability" and negative risk or threat. In professional risk assessments [7, 61], risk combines the probability of an event with the impact the event would have for an assumed *risk scenario*. In particular, financial risk is often considered as the unexpected variability or volatility of revenues (which can be worse or better than expected). Note that risk-oriented evaluation approaches are not further considered in the context of this survey.

3 Comparing IT Evaluation Approaches

This section introduces the conceptual framework we use for classifying and comparing economic-driven IT evaluation approaches[1].

3.1 Existing Frameworks

In literature, there exist several frameworks that aim at comparing IT evaluation approaches:

- ***Andresen's Framework*** [3]: This framework is based on nine criteria. Criterion 1 (*extent of involvement*) deals with the question which persons or user groups are affected when applying the evaluation approach. Criterion 2 (*stage of IT evaluation*) concerns the question at which project stage an evaluation approach can be used. Criterion 3 (*type of impact*) addresses the effects that can be analyzed with an evaluation approach. Criterion 4 (*costs of a method*) deals with the effort related to the use of an approach. Criterion 5 (*number and type of evaluation*) concerns the theoretical foundation of an evaluation approach. Criterion 6 (*type of investment*) deals with the question to what kind of IT investment an approach can be applied. Criterion 7 (*scope of IT evaluation*) concerns the enterprise level an approach is tailored to (e.g., management, operational departments). Criterion 8 (*difficulty*) deals with the complexity related to the application of an evaluation approach. Finally, Criterion 9 (*type of outcome*) analyzes in which way evaluation results are presented.

- ***Pietsch's Framework*** [60]: This framework utilizes ten criteria, many of them addressing the same or similar issues as Andresen's criteria: theoretical foundation, evaluation object and scope, sources of evaluation data, stage of IT evaluation, flexibility, costs of an approach, tool support, transparency and traceability, completeness, and relevance for practice.

- Besides, there are enterprise architecture frameworks, e.g., *Zachman's framework* [81] or the *GRAAL framework* [78, 80], which also address potential criteria for comparing IT evaluation approaches.

3.2 Our Framework

Though these frameworks address many important characteristics of IT evaluation approaches, they also neglect other basic issues. As examples consider the data needed for using an evaluation approach, the ability of an evaluation approach to allow for plausible conclusions, the objectiveness of an evaluation approach (and its resistance against manipulation), or the sensitivity of an evaluation approach when being confronted with an evolving information baseline (i.e., a varying data quality).

For these reasons, we have developed an adopted conceptual framework which combines criteria of the above frameworks with additional criteria derived from a profound literature study on economic-driven IT evaluation and practical needs we have identified in an empirical study [56].

Fig. 3 shows our framework. Basic to this framework is the distinction between *classification criteria* and *evaluation criteria*. While the former allow for the categorization of approaches (based on identified similarities and differences), the latter enable us to analyze the general features of considered evaluation approaches.

3.2.1 Classification Criteria

This section summarizes criteria which can be used to classify IT evaluation approaches:

- **Criterion C-1:** ***Evaluation Viewpoint***. We distinguish between three basic evaluation viewpoints. Ap-

[1] Note that software cost estimation approaches like Boehm's *constructive cost model* (COCOMO) [11, 13] and Putnam's *software life cycle management* (SLIM) [63] are not considered in this survey.

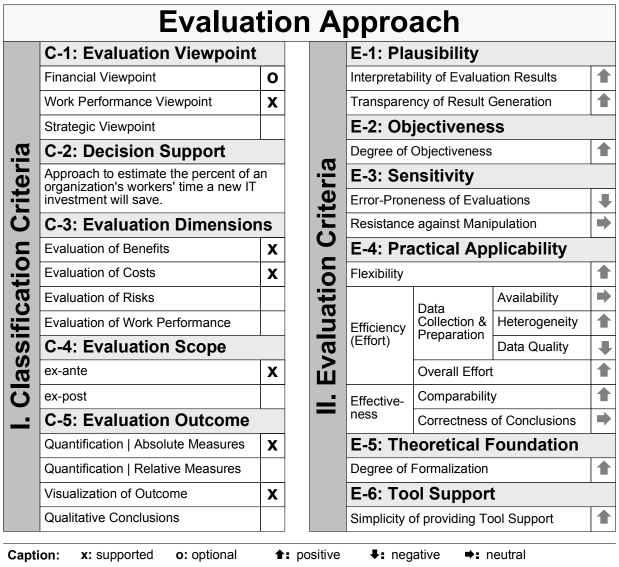

Figure 3. The Criteria Framework at a Glance.

proaches for analyzing an IT investment from the *financial viewpoint* deal with the evaluation, distribution, and consumption of financial value. Approaches for investigating IT investments from a *work performance viewpoint* evaluate the impact of an IT investment on work performance and business process performance. Finally, approaches for conducting evaluations from a *strategic viewpoint* allow to analyze the impact of an IT investment on the achievement of strategic enterprise objectives.

- **Criterion C-2:** ***Decision Support***. It is the goal of most evaluation approaches to support decision making (e.g., investment decisions, project decisions, etc.) [46, 47]. Picking up this issue, we consider the suitability of an evaluation approach to support decisions as classification criterion.

- **Criterion C-3:** ***Evaluation Dimensions***. This criterion deals with the evaluation dimension that can be analyzed by an evaluation approach. In our framework, we distinguish between the evaluation of *costs*, *benefits*, *risks*, and *work performance*.

- **Criterion C-4:** ***Evaluation Scope***. We distinguish between ex-ante and ex-post evaluations. *Ex-ante evaluations* aim at the identification of the best solution in a given context. They focus on the economic feasibility of an investment, and they are typically conducted prior to an investment. However, they can also be used for evaluating an already initiated investment. Note that the accuracy of ex-ante evaluations increases with the number of available parameters (cf. Fig. 4). *Ex-post evaluations*, by contrast, justify assumptions made during an ex-ante analysis, i.e., ex-post evaluations typically confirm or discard the results of a previous ex-ante evaluation.

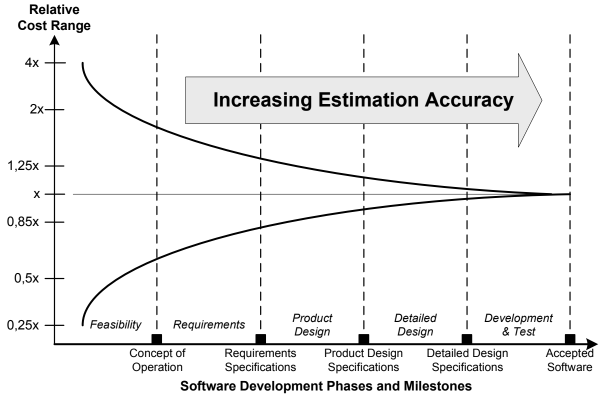

Figure 4. Accuracy of Estimations.

- **Criterion C-5:** ***Evaluation Outcome***. We distinguish between four types of evaluation outcome: (1) *absolute figures* (i.e., single numbers, calculated sums or differences), (2) *relative figures* (relating two absolute figures and analyzing their correlation), (3) *graphical representations* (i.e., tables, charts, and outlines for illustrating and visualizing both absolute and relative figures), and (4) *textual evaluations*.

These five criteria allow for the classification of IT evaluation approaches. Note that our discussions of specific evaluation approaches (Sections 4, 5 and 6) is organized along the three viewpoints of criterion C-1.

3.2.2 Evaluation Criteria

Before dealing with selected approaches in detail, we introduce criteria for evaluating the considered approaches. Again, most evaluation criteria comprise sub criteria:

- **Criterion E-1:** ***Plausibility***. This criterion deals with the ability of an evaluation approach to derive plausible results. Plausibility is determined by two sub criteria: (1) *interpretability of results* and (2) *transparency of result generation*. While the former addresses the clarity of evaluation results, the latter deals with the traceability of deriving an evaluation.

- **Criterion E-2:** ***Objectiveness***. This criterion deals with the ability of an evaluation approach to produce the same or at least similar results when it is applied (to the same context) by different users. Approaches enhancing a high degree of objectiveness exhibit fewer opportunities for manipulation.

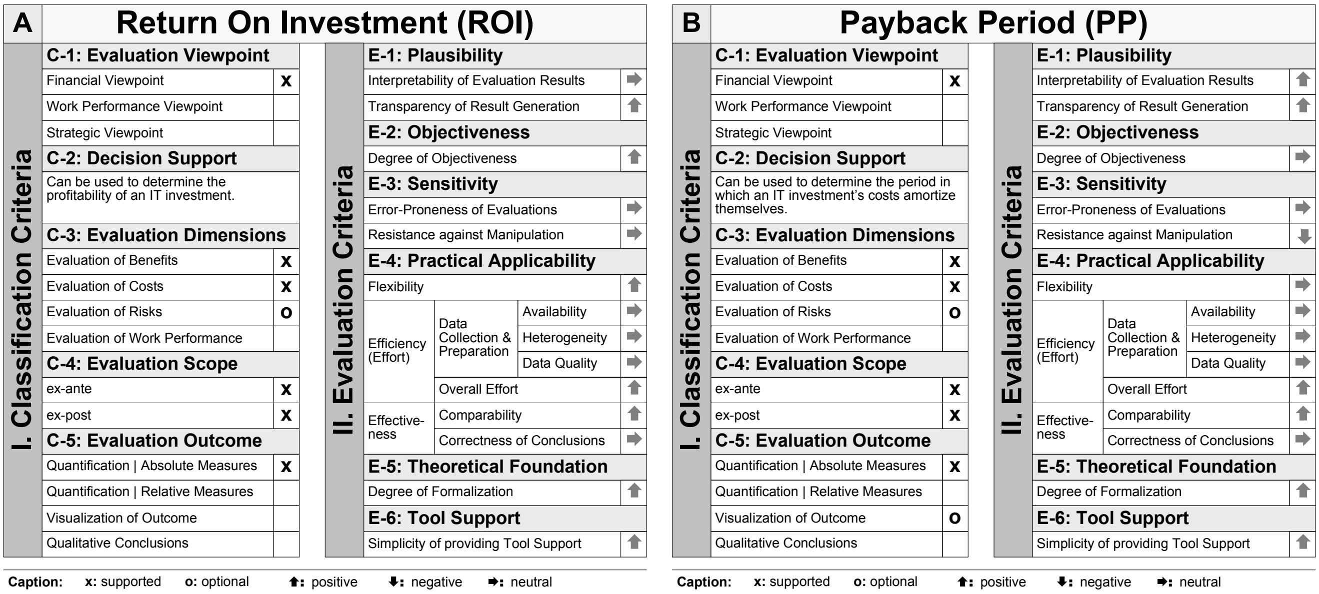

Figure 5. Return on Investment and Payback Period.

- **Criterion E-3:** ***Sensitivity***. This criterion concerns changes in evaluation results when underlying evaluation data is modified. High sensitivity means that small modifications of evaluation data can result in significant changes. Low sensitivity, in turn, implies that even strong modifications of evaluation data do not lead to strong changes. Thus, this criterion will be a measure for the *error-proneness*, if evaluation data is incomplete. Furthermore, this criterion also allows — like the previous criterion — to draw conclusions regarding the resistance of an evaluation approach against manipulation.

- **Criterion E-4:** ***Practical Applicability***. Three sub criteria determine the practical applicability of an evaluation approach: (1) the ability of an evaluation approach to meet the varying requirements of different application domains (i.e., its *flexibility*), (2) the efforts for accomplishing an evaluation (i.e., its *efficiency*), and (3) the ability of an evaluation approach to derive correct results (i.e., its *effectiveness*).

- **Criterion E-5:** ***Theoretical Foundation***. Theoretical foundation enhances objectiveness.

- **Criterion E-6:** ***Tool Support***. Tool support is an important criterion as well.

4 Financial Viewpoint

This section discusses approaches that can be used to accomplish evaluations from a financial viewpoint (cf. Criterion C-1). In particular, this viewpoint deals with the creation, distribution, consumption, and evaluation of economic value. It concerns the prediction of revenues and expenses based on the exchange of valuable goods and services between multiple actors. Evaluations from the financial viewpoint are typically based on traditional budgeting models and financial business ratios [61, 66]. These models and ratios consider the monetary costs and benefits of an investment over a specified period of time.

Thereby, we distinguish between static approaches (Section 4.1), dynamic approaches (Section 4.2), and cost-oriented approaches (Section 4.3). Note that the approaches discussed in the following can be used to analyze any economic investment.

4.1 Static Business Ratios

Static approaches ignore the time value of money. As examples we consider *return on investment*, *payback period*, *accounting rate of return*, and *break even analysis*.

Return on Investment: Due to its simple calculation, *return on investment* (ROI) has become one of the most popular ratios to understand, evaluate and compare the economic value of different IT investment options. It measures the economic return of an investment, i.e., the effectiveness of using money to generate profit. More precisely, ROI describes how many times the net benefits of an investment (i.e., its benefits minus its initial and ongoing costs) cover the original investment:

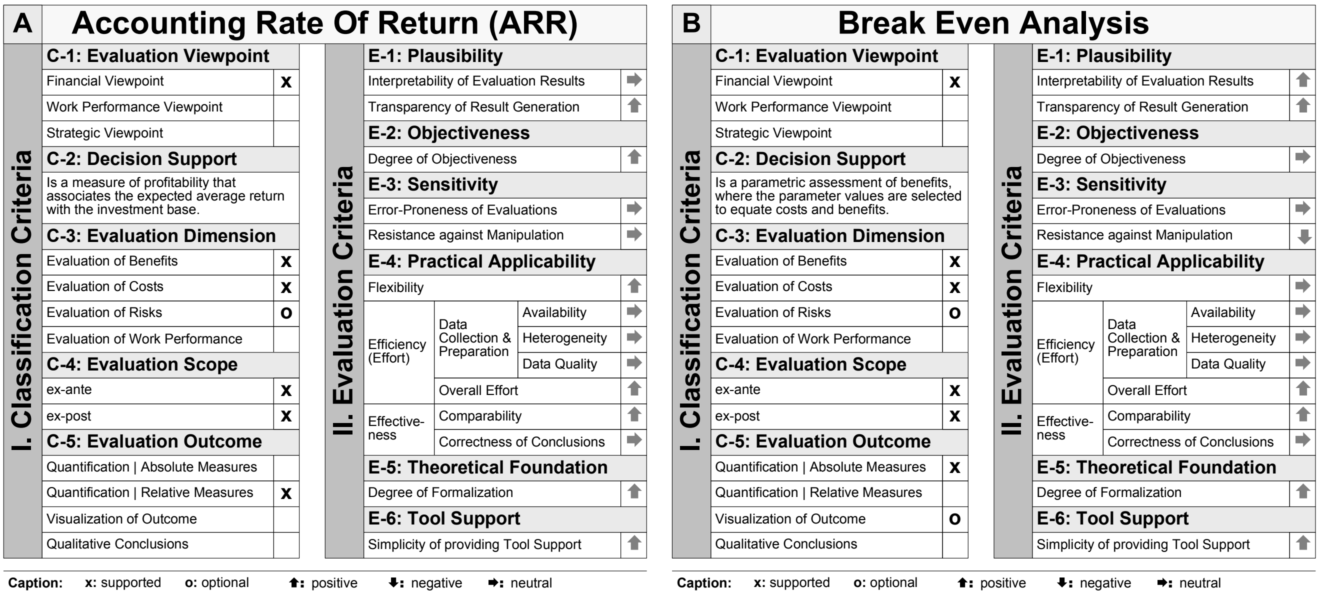

Figure 6. Accounting Rate of Return and Break Even Analysis.

$$\text{ROI} = \frac{Benefits - Costs}{Costs} * 100\%$$

There exist many variations of this definition [38] considering the multiple interpretations and applications in different industry domains, e.g., the *return on invested capital* (ROIC) or the *financial ROI*.

Fig. 5A shows the evaluation[2] of ROI based on our framework (cf. Section 3.2). Regarding the classification criteria (on the left side), ROI is an approach which can be related to the financial viewpoint (C-1). ROI takes into account both costs and benefits and — in certain variants — risks (C-3). Thereby, ROI supports both ex-ante and ex-post evaluations (C-4) and its result is an absolute measure (C-5). Besides, the evaluation criteria (on the right side) allow to assess the ROI approach. Criterion E-1 in Fig. 5A, for example, expresses that the transparency of ROI result generation is easy to understand, while the interpretability of evaluation results can be considered neither as simple (i.e., positive) nor difficult (i.e., negative). Furthermore, the degree of objectiveness is high (E-2) and providing tool support is simple (E-6).

Payback Period: The *payback period* (cf. Fig. 5B) is the length of time required to compensate the original investment through its cash flows:

$$\text{Payback Period} = \frac{Investment}{CashflowPerYear}$$

It is assumed that the investment with earliest payback period is the best one. However, this is not always reasonable for investments with large expected benefits in the future. The payback period is a simple measure, but has its limitations. In particular, it neither address the time value of money nor does it consider anything else than the compensation of the initial investment. Fig. 5B shows the evaluation of the payback period approach based on our framework (cf. Section 3.2).

Accounting Rate of Return: The *accounting rate of return* (cf. Fig. 5C) is a measure of profitability that associates the expected average return with the investment base. This ratio uses projected earnings based on financial statements rather than on cash flows:

$$\text{Accounting Rate of Return} = \frac{ExpectedAnnualEarnings}{AverageInvestment}$$

"Expected Annual Earnings" denotes the expected annual income from the investment (or the average difference between revenues and expenses), and "Average Investment" is the average or initial investment.

Break Even Analysis: The *break even analysis* (cf. Fig. 6B) is used when costs are quantifiable, but some key benefits are uncertain or intangible. It is particularly useful when the calculated break even level is "extreme", i.e., when it is outside the range of expected benefits.

4.2 Dynamic Business Ratios

Dynamic approaches consider the time value of money by comparing the initial cash outflows (or expenses) prior to

[2] Note that in the following, we will not discuss these criteria in detail for the considered approaches.

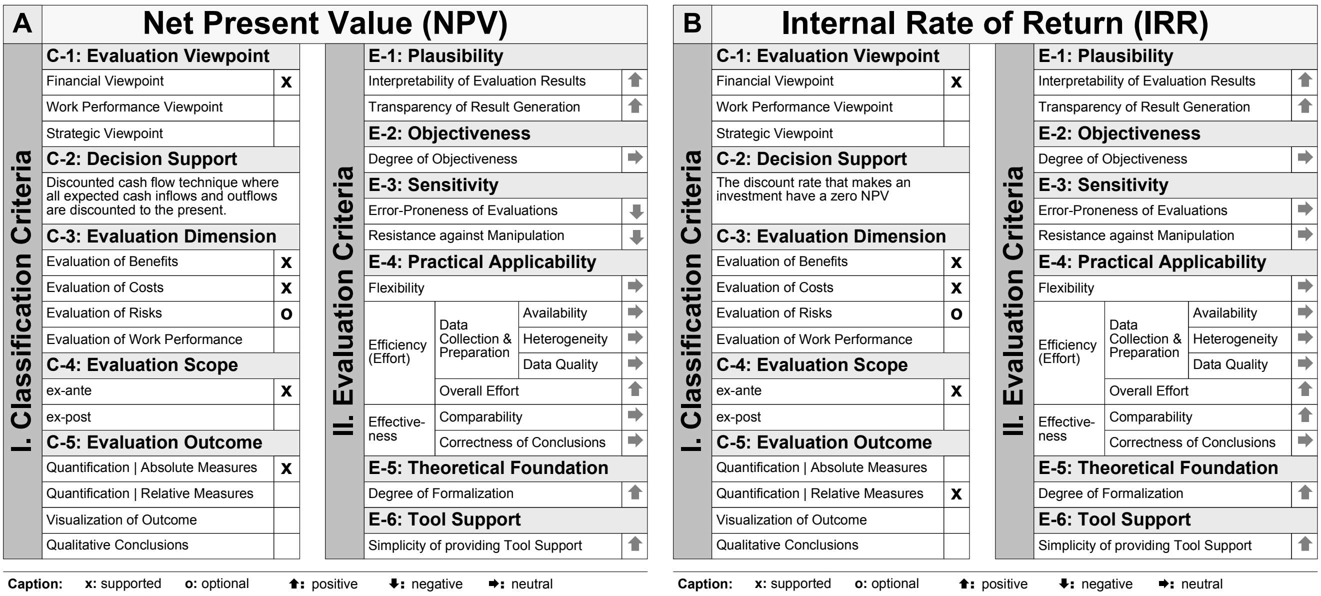

Figure 7. Net Present Value and Internal Rate of Return.

an investment with the expected cash inflows (or revenues) of the investment. As examples consider *net present value* and *internal rate of return*.

Net Present Value: The *net present value* (NPV) (cf. Fig. 7A) is a technique where all expected cash outflows and inflows are discounted to the present point in time. This is done by applying a discount rate to the difference of all expected inflows and outflows (the NPV is calculated from the current time t_0 to some future point in time T):

$$\mathrm{NPV} = \sum_{i=0}^{T} \frac{B_i - C_i}{(1+d)^i}$$

Thereby, $\mathrm{B_i}$ is the assumed benefit for the $\mathrm{i^{th}}$ period in the future (i.e., the sum of the expected revenues), whereas $\mathrm{C_i}$ denotes the assumed costs for the same period (i.e., the sum of the expected outflows). "d" is the discount factor.

The values of all expected inflows are added together, and all outflows are subtracted. The difference between the inflows and the outflows is the net present value. Generally, only investments with a positive NPV are acceptable as their return exceeds the discount rate.

Internal Rate of Return: As another example of a dynamic budgeting model consider the *internal rate of return* (IRR) (cf. Fig. 7B). IRR is the annual rate at which an investment is estimated to pay off.

IRR and NPV are related though not equivalent. In particular, IRR does not use a discount rate. Instead, IRR takes into account the time value of money by considering the cash flows over the lifetime of an investment.

4.3 Cost-oriented Approaches

The approaches discussed in the following focus on the analysis and justification of IT investment costs: *zero base budgeting approach*, *cost effectiveness analysis*, *target costing approach*, and *total cost of ownership approach*. Note that all these approaches go beyond the scope of the approaches discussed in Section 4.1 and Section 4.2.

Zero Base Budgeting. The *zero base budgeting* approach (cf. Fig. 8A) is a budgeting method. It assumes that all costs of an investment have to be justified for each new period (e.g., a month, a quarter, a year), i.e., fundings are continuously justified [60, 83].

Cost Effectiveness Analysis. Based on a *cost effectiveness analysis* (cf. Fig. 8B), one can compare and select the best out of several investment options [71]. A scoring model identifies key performance criteria for the candidate investments, assigns a score to each criterion, and finally computes a weighted overall score for each candidate investment. This requires the explicit identification, measurement and weighting of important decision factors based on subjective assessments.

Generally, cost effective analysis can be applied to different scenarios. A first scenario may be to minimize costs for a given level of effectiveness. As an example consider the choice among several printers. Each printer may be equally effective, and the issue is to choose the one with the lowest expected life cycle costs. A second scenario may be to maximize effectiveness for a given amount of costs. As an ex-

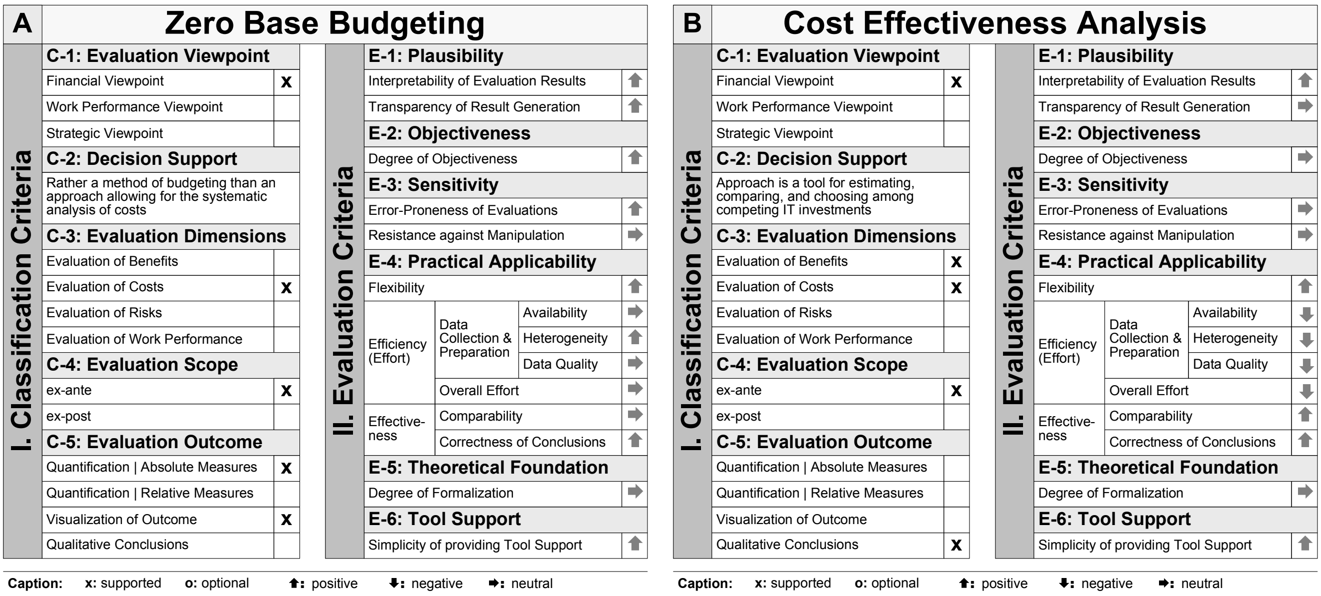

Figure 8. Zero Base Budgeting and Cost Effectiveness Analysis.

ample consider the choice among several database management systems, where costs are identical, but features vary. A final scenario may be to maximize effectiveness and minimize costs at the same time. As an example consider the selection of an engineering workstation where both performance features and costs might differ significantly.

This approach will be particularly useful if the benefits of an investment are quantifiable mainly in non-monetary dimensions. It does not allow for justifying an investment, i.e., it does not explicitly address the question whether the benefits of an investment exceed its costs.

Total Cost of Ownership. The *total cost of ownership (TCO) approach* (cf. Fig. 9A) is a method to assess direct and indirect costs related to an investment [61]. A TCO assessment ideally results in a statement reflecting not only purchase costs, but also costs related to the future use and maintenance of the investment (as long as these costs can be made explicit). This includes costs caused by (planned and unplanned) failure or outage, costs for diminished performance incidents (i.e., if users are kept waiting), costs for security breaches (in loss of reputation and recovery costs), costs for disaster preparedness and recovery, floor space, electricity, development expenses, testing infrastructure and expenses, quality assurance, incremental growth, and decommissioning. Often, TCO is used in financial analysis, e.g., ROI or IRR calculations, to quantify costs.

Target Costing. *Target costing* (cf. Fig. 9B) is a technique for planning and realizing a defined amount of costs at which a product with a specified functionality has to be produced to generate profitability [60, 73]. Besides, it also allows for identifying cost reductions by focusing on major ”design drivers” that influence costs. Therefore, target costing integrates strategic business and profit planning, competitive research and analysis, market research and customer requirements, research and development, technology advances, and product development. Target costing uses *product portfolio profit plans* to provide strategic summary schedules for product development, introduction and replacement, or IT investments. Generally, target costing is different from a simple expenditure control mechanism as it aims at determining market-based prices for envelopes of features based upon market and competitive conditions in which price/volume relationships are examined.

5 Process Viewpoint

The process viewpoint focuses on the evaluation of operational work and business process performance [37, 46, 47, 48, 57]. Characteristic to all approaches described in the following are quantifications based on information about process/work activities (e.g., start/completion times, average duration times, or waiting and idle times), process/work resources (e.g., resources needed, input and output data, or size of work queues), and quality metrics (e.g., failed or successful processes/work activities).

In the following, we describe four approaches: *times savings times salary approach* (Section 5.1), *hedonic wage model* (Section 5.2), *activity-based costing* (Section 5.3), and *business process intelligence* (Section 5.4).

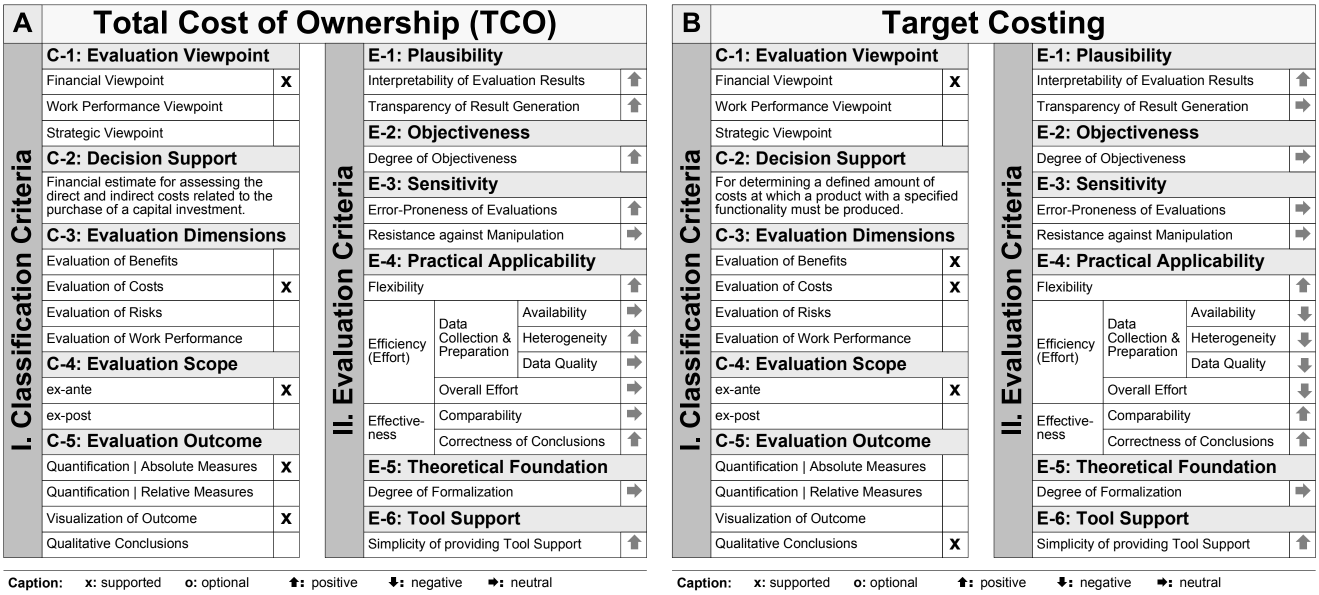

Figure 9. Total Cost of Ownership and Target Costing.

5.1 Times Savings Times Salary Approach

The *times savings times salary* (TSTS) approach (cf. Fig. 13A) [70, 71] is based on the assumption that an employee's salary is a measure of his "contribution" or "value" to an organization. Its goal is to estimate the work time an IT investment (e.g., a new information system) will save, and then to multiply that time with the salaries of all affected employees. For example, if an employee is currently devoting x_j hours per week to activity a_j, and if a new IT investment saves a total of Y% of his time, and if that saving includes y_j hours in activity a_j, then the change in the amount of time the employee will devote to activity a_j can be calculated as follows [70]:

$$dx_j = Y(\%) * (x_j - y_j) - y_j$$

The TSTS approach is based on five premises. *First*, it assumes that an employee's value corresponds to his costs for an organization. *Second*, it assumes that saving x percent of an employee's time is worth x percent of the employee's costs. *Third*, it is based on the assumption that the resources of an organization are efficiently allocated, i.e., that the costs of additional employees are balanced against their value for an organization. Consequently, the number of employees would not be higher even if it had been possible to hire additional employees. *Fourth*, the TSTS approach assumes that work comparable in value to current work remains to be done. In other words, it is assumed that there is additional work to which any saved time could be devoted, and that the value of work is comparable to work currently done. *Fifth*, it assumes that saved time will be allocated among an employee's productive activities.

The TSTS approach is easy to accomplish. As it is time-based, it can be used for evaluating the impact of IT on work performance and also on business process performance. However, there are three major problems derogating its use in practice. *First*, it is assumed that an employee's value corresponds to his cost to an organization. This will be true if the organization is not resource-constrained and has hired the optimal number of employees. However, in general, the possibility that an employee's value exceeds his costs should not be automatically dismissed. If his value is greater than his cost, then this approach will underestimate the true value of saved time. *Second*, and more important, the TSTS approach does not take into account how the saved time is used. Instead, it is implicitly assumed that saved time is efficiently reallocated among available work activities. Consequently, it cannot be assumed that a particular time allocation will take effect. *Third*, the calculation of the saved time implies that benefits are automatically realized. However, typically they are not, i.e., saved time may not result in economic benefit. The value of a new IT investment, for example, may be low or high, depending on how an organization and its flow of work is managed. The TSTS approach does not capture this variability.

5.2 Hedonic Wage Model

Like the TSTS approach, the *hedonic wage model* (cf. Fig. 13B) [70] assumes that employees perform activities of different intrinsic value. The value of an IT investment, in particular, is determined by its ability to restructure existing work patterns and to cause a shift in an employee's work profile by replacing low-value-activities with tasks in a higher category. Such a restructuring can not only increase the efficiency (doing more of the same thing in the same amount of time) but also the effectiveness (doing more valuable work) of an organization and its employees.

The hedonic wage model assumes that employees carries out categories of activities (together making up his work profile). The aggregation of all work profiles into one *work profile matrix* (cf. Fig. 10) characterizes the work profile of an organization (with the *level in the job hierarchy* as the first dimension and the *type of activity* as the second one).

Note that both the number of job levels and activity types (i.e., the dimensions of the work profile matrix) are organization-specific, i.e., they may differ. In the example from Fig. 10, there exist five job levels (managers, specialists, clerks, assistants, and secretaries) and six types of activities (management activity, specialist activity, routine activity, assistant activity, service activity, and other activity). Each value in Fig. 10 specifies how much time (in %) an employee (belonging to one of the five job levels) uses to conduct the six considered activities.

Level in Job Hierarchy	Type of Activity: Management Activity (T1)	Specialist Activity (T2)	Routine Activity (T3)	Assistant Activity (T4)	Service Activity (T5)	Other Activity (T6)	Wage per Hour
Manager (S1)	53%	18%	23%	2%	2%	2%	160€
Specialist (S2)	13%	54%	13%	7%	2%	2%	120€
Clerk (S3)	5%	18%	26%	17%	15%	7%	80€
Assistant (S4)	0%	0%	13%	55%	27%	5%	60€
Secretary (S5)	0%	0%	0%	15%	70%	15%	45€

Each clerk utilizes (in average) 18% of his work time for specialist activities

Figure 10. Initial Work Profile Matrix.

From this matrix, a linear system of equations is derived (cf. Fig. 11). Solving this system of equations (not shown here), it becomes possible to determine the value of the different activities [70]. In Fig. 11 a manager (job level S1), for example, has a value of 230.62$/h for the organization, but generates only costs of 160$ (his average wage per hour).

Linear System:

$$\left.\begin{array}{l} \textbf{S1}: 0.50T1+0.15T2+0.20T3+0.05T4+0.05T5+0.05T6 = 160.00\text{ €/h} \\ \textbf{S2}: 0.10T1+0.60T2+0.10T3+0.10T4+0.05T5+0.05T6 = 120.00\text{ €/h} \\ \textbf{S3}: 0.02T1+0.15T2+0.35T3+0.20T4+0.18T5+0.10T6 = 80.00\text{ €/h} \\ \textbf{S4}: 0.00T1+0.00T2+0.10T3+0.55T4+0.30T5+0.05T6 = 60.00\text{ €/h} \\ \textbf{S5}: 0.00T1+0.00T2+0.00T3+0.15T4+0.70T5+0.15T6 = 45.00\text{ €/h} \end{array}\right\} \textbf{Value} \left\{\begin{array}{l} 230{,}62\text{ \$/h} \\ 130{,}55\text{ \$/h} \\ 96{,}93\text{ \$/h} \\ 63{,}87\text{ \$/h} \\ 50{,}60\text{ \$€/h} \end{array}\right.$$

Figure 11. Linear System of Equations.

The value of an IT investment is derived based on a second work profile matrix. This second matrix reflects the (assumed) change in the work profile of an organization (caused by the investment). It is also converted into a linear system of equations which is then solved. The value of the IT investment can be determined by comparing values of job levels before and after the investment.

Level in Job Hierarchy	Type of Activity: Management Activity (T1)	Specialist Activity (T2)	Routine Activity (T3)	Assistant Activity (T4)	Service Activity (T5)	Other Activity (T6)	Wage per Hour
Manager (S1)	50%	15%	20%	5%	5%	5%	160€
Specialist (S2)	10%	60%	10%	10%	5%	5%	120€
Clerk (S3)	2%	15%	35%	20%	18%	10%	80€
Assistant (S4)	0%	0%	10%	55%	30%	5%	60€
Secretary (S5)	0%	0%	0%	15%	70%	15%	45€

Figure 12. Second Work Profile Matrix.

The hedonic wage model is similar to the TSTS approach, but avoids certain restrictive assumptions. For example, it produces more accurate value estimates. By estimating pre- and post-implementation work profile matrices, the projected values can be audited. However, disadvantages like the insufficient evaluation of qualitative factors remain.

5.3 Activity-based Costing

Activity-based costing (ABC) (cf. Fig. 15A) is a method of allocating costs to products and services. ABC helps to identify areas of high overhead costs per unit and therewith to find ways to reduce costs. Generally, ABC comprises the following steps:

- ***Step 1***: The *scope of the activities to be analyzed* has to be identified (e.g., based on activity decomposition).
- ***Step 2***: The identified *activities are classified*. Typically, one distinguishes between *value adding* or *non-value adding* activities, between *primary* or *secondary* activities, and between *required* or *non-required* activities. An activity will be considered as value-adding if the output of the activity is directly related to customer requirements, services or products (as opposed to administrative or logistical outcomes). Primary activities directly support the goals of an organization (whereas secondary activities support primary ones). Required activities are those that must always be performed.
- ***Step 3***: *Costs are gathered* for those activities creating the products or services of an organization. These costs can be related to salaries and expenditures for research, machinery, or office furniture.
- ***Step 4***: *Activities and costs are combined* and the total input cost for each activity is derived. This allows for calculating the total costs consumed by an activity. However, at this stage, only costs are calculated. It is not yet determined where the costs originate from.
- ***Step 5***: *The "activity unit cost" is calculated*. Though activities may have multiple outputs, one output is

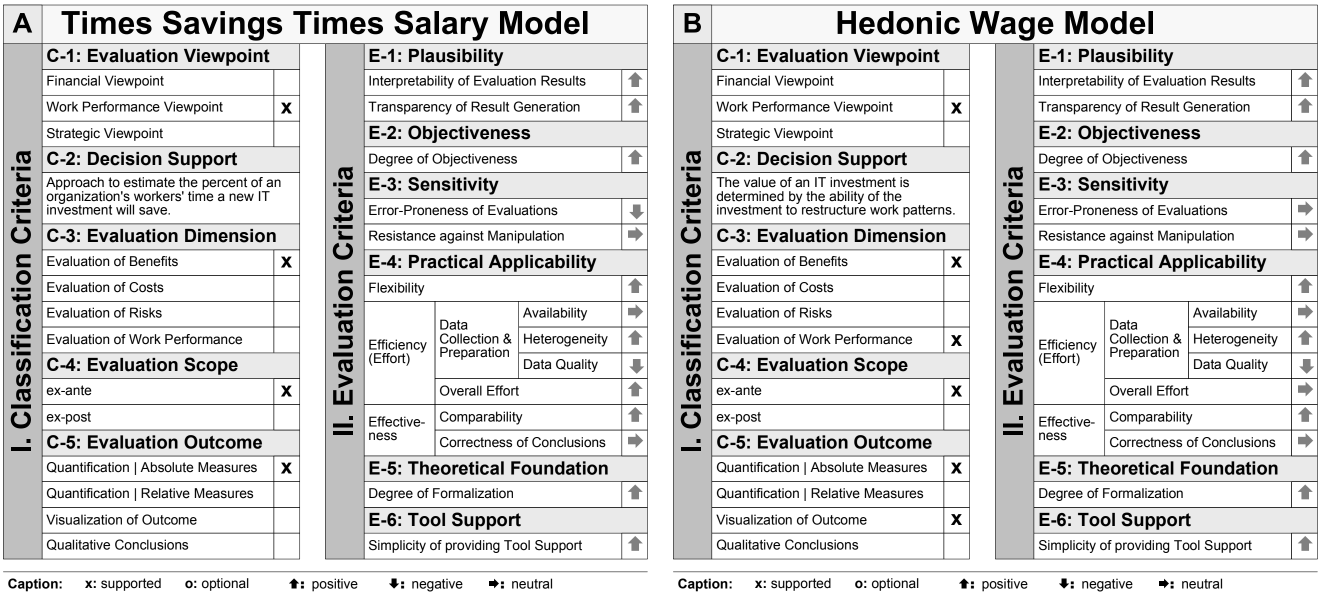

Figure 13. Times Savings Times Salary Approach and Hedonic Wage Model.

identified as the primary one. The ”activity unit cost” is calculated by dividing the total input cost (including assigned costs from secondary activities) by the primary activity output. Note that the primary output must be measurable and its volume or quantity obtainable. From this, a ”bill of activities” is derived which contains a set of activities and the amount of costs consumed by each activity. Then, the amount of each consumed activity is extended by the activity unit cost and is added up as a total cost for the bill of activity.

- ***Step 6***: The calculated activity unit costs and bills of activity are used for *identifying candidates for business process improvement*.

ABC is an approach to systematically analyze the ”true” costs related to activities. However, the correct accomplishment of an ABC analysis causes significant efforts and requires a lot of experience. Often, it may be not transparent, for example, which costs are caused by which activity.

5.4 Business Process Intelligence

Enterprises are aiming at continuous optimizations of their business processes [22, 28, 79]. An important factor in this context is the availability of adequate metrics. DeMarco stated in 1983: ”You can’t manage what you can’t control, and you can’t control what you can’t measure” [25]. This also applies for business processes. In order to effectively manage them, process logic has to be explicitly defined at build-time and process instances have to be flexibly controlled during run-time (e.g. using process management systems). A promising approach in this respect is providing *business process intelligence* (BPI) concepts.

BPI applies business intelligence concepts (e.g., analytical applications) to processes [21, 33, 39, 72]. It is based on the analysis of process execution data (e.g., related to the start and completion of process activities, or the resources needed by a process activity) and the automatic derivation of (optimized) process models and performance characteristics from these data. It is implemented as a set of integrated tools providing features for the analysis, mining, prediction, control, and optimization of processes. Its overall goal is to extend performance management to business processes (cf. Fig. 15B). We discuss BPI in detail along a conceptual reference architecture [52, 50]. This architecture comprises three major levels (cf. Fig. 14).

Level 1 is responsible for the extraction of process execution data from the information systems supporting the monitored business processes. Typically, the implementation of a particular business process is scattered over heterogeneous information systems each of them using a different representation for process log files. While some information system provide event-based execution logs (audit trails [84]) with detailed information, others maintain only simple process logs. Therefore, the syntactical and semantic integration of these log data is a challenging task. In practice, very often message brokers and ”extract transform load” (ETL) modules (known from data warehousing) are used for this purpose. Furthermore, a central *repository* (*process warehouse*) stores collected control and application data generated during real process executions. Besides, estimated reference values (e.g., derived from process simulations) can be stored in a database (called *process warehouse* [84]) what allows for delta analysis (i.e., comparison of estimated reference and real process data).

Level 2 of our reference architecture (cf. Fig. 14) implements BPI *core functions*. In order to measure and evaluate process performance, the *processing unit* aggregates and calculates *key performance indicators* (KPI) (e.g., process cycle time or number of processes completed within a given period of time) based on the data provided by the process warehouse. To be able to quickly react to critical process events (e.g., lack of resources needed to complete a process step) the *notification component* provides functions to send messages to relevant persons (e.g., the process administrator). To deal with confidential data, a *security component* controls the access to (aggregated) process data (e.g., through generated process views). Similar issues are known from data warehousing. The *process mining component* is responsible for the automated derivation of (optimized) process models based on logged execution data (e.g., by algorithms and tools). Thereby, the correct induction of process models depends on the completeness and quality of available process log data. Finally, the *administration component* provides support functions, e.g., for user management.

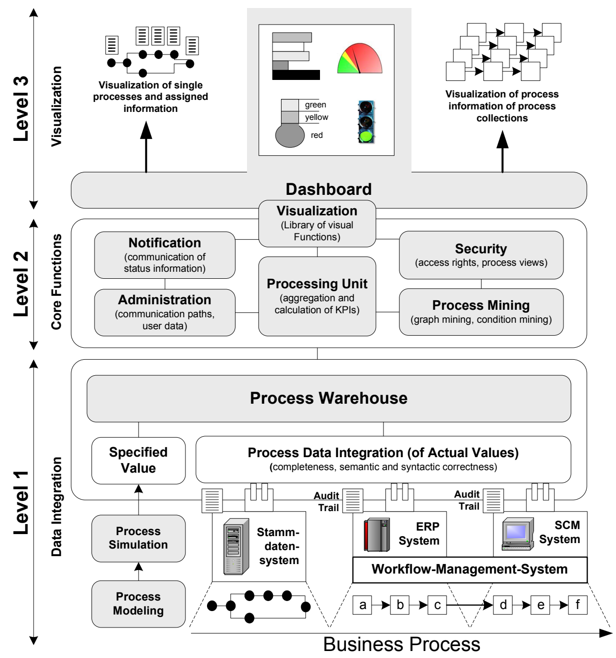

Figure 14. Reference Architecture.

Level 3 (cf. Fig. 14) is responsible for the *visualization* of processes and aggregated process information (i.e., information about a collection of process instances). The *visualization component* is providing a library of presentation elements (e.g., traffic lights or bar charts) for the design of user-specific presentation forms (dashboards).

This reference architecture can be applied using contemporary BPI tools. Examples of such tools include *Websphere Business Integration Monitor*, *ARIS Process Performance Manager*, and *BizTalk Server Business Activity Monitoring Framework*. Table 1 benchmarks BPI features of these tools[3] from very positive ”++” to very negative ”–”. All of them assume the availability of event-based process execution data. Contemporary BPI tools, however, do not cover all aspects of the described architecture (e.g., data integration). Therefore, other software tools (e.g., message broker) are needed as well.

Evaluation Criterion	ARIS -PPM	WBI -Monitor	BizTalk (BAM)	ADO score
Degree of Details	+	+	++	–
Process Visualization	++	+	–	– –
Modification	–	+	–	+
Delegation Possibilities	– –	++	– –	– –
Analysis Possibilities	++	–	++	–
Simulation Possibilities	– –	– –	– –	– –
Information Transfer	+	+	+	+
Border Value Definition	+	+	–	–
Result Commentation	++	– –	– –	– –
Cross-application Monitoring	++	– –	–	+
Cross-organizational Monitoring	++	–	–	+
Portability	+	+	– –	
Security Support	–	–		
System Requirements	+	+	+	
Administration	+			

Table 1. Tool Features [41].

BPI tools utilize metrics to derive (aggregated) process information and to generate status reports. In the following we introduce three use cases for BPI and discuss the benefits arising in this context (cf. Fig. 16):

- **Use Case 1: *Information System Alignment*.** BPI can be used to support the development and maintenance of process-oriented information systems. In particular, it provides valuable information for aligning the information systems to the business processes (e.g., information about the adequacy of provided business functions [40]).
- **Use Case 2: *Business Process Optimization*.** BPI can be used to identify ”critical” scenarios that may occur during the execution of a business process (e.g., non-availability of resources, unnecessary waiting and idle times). Process mining [77, 34] as an important BPI concept allows for the continuous derivation of optimized process models. This, in turn, reduces the total effort necessary for ”manual” process analyses. As optimizations are based on real data, their implementation tend to be much more effective than other

[3] A detailed study including a comparison of the features, strengths, and limitations of existing BPI tools can be found in [41].

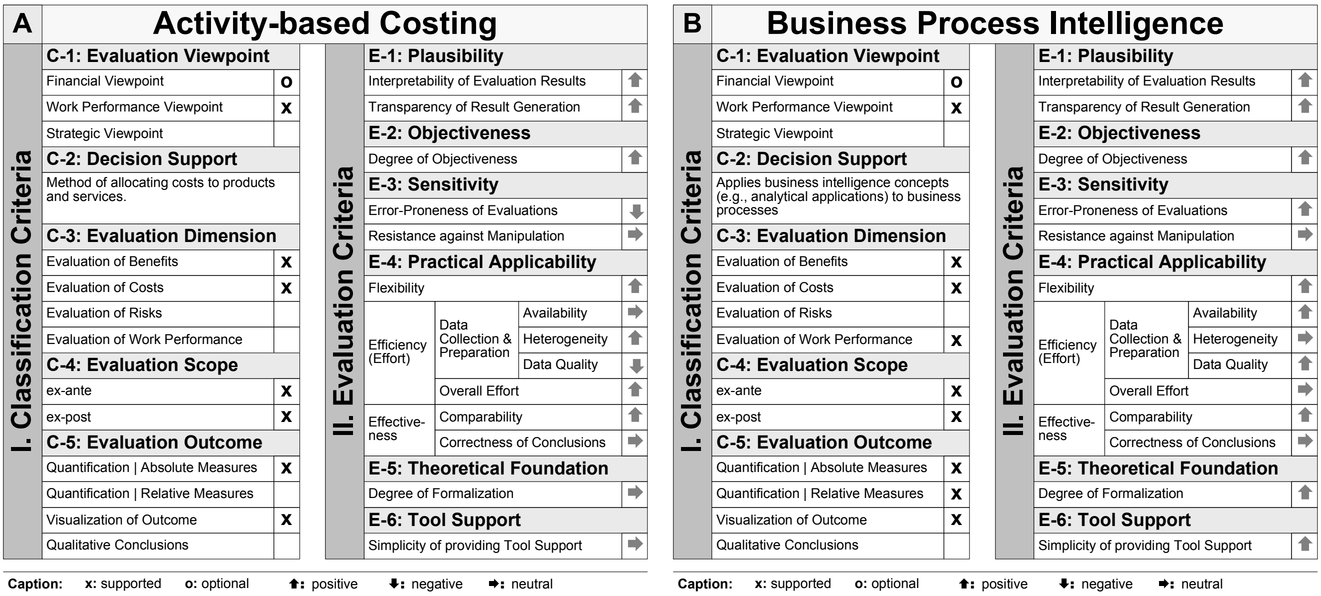

Figure 15. Activity-based Costing and Business Process Intelligence.

approaches (e.g., the disclosure of optimization potentials by process simulation based on estimated data).

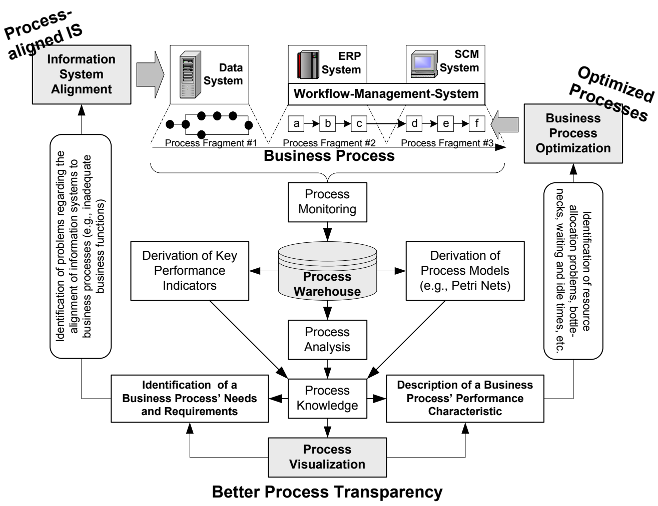

Figure 16. Realization of BPI Benefits.

- **Use Case 3:** ***Visualization of Process Information***: Due to the fragmented support of business processes, their control is distributed over several operational systems, i.e., we cannot always assure that controlled execution by one control system (e.g., process management system) is possible. Nevertheless, when collecting the respective log data from the different systems, it becomes possible to provide monitoring and visualization support for the overall business process [10, 43]. The information to be visualized include complete process schemas and process instances (e.g., control and data flows, activity states) as well as other process-related data (e.g., application data) [9, 69, 68]. Most BPI tools include features to visualize processes and related aspects. ARIS PPM, for example, offers a detailed tree view to illustrate the hierarchical relationships between processes and sub processes. Particularly the analysis of entire process maps becomes easier using such or comparable features.

BPI tools support a broad spectrum of use cases. Currently there is a growing interest in BPI tools of both vendors and customers. However, BPI is a technology that enables the measurement of business process performance. It is not a methodology like the TSTS approach or the hedonic wage model that allow for evaluating the effects of an IT investment prior to this investment. As it requires the availability of real process execution data, it can be mainly only used for a-posteriori assessments.

6 Strategic Viewpoint

In the previous sections we have discussed approaches that can be used to evaluate IT investments from either a financial or a work performance viewpoint. In this section, we discuss approaches that can be used to evaluate IT investments from a strategic viewpoint, e.g., regarding their contribution to the achievement of strategic enterprise objectives [75, 23]. However, strategy evaluation is a complex task as the strategic impact of IT investments is confronted with a considerable measure of uncertainty.

In the following, we describe four evaluation approaches: *Nolan's approach* (Section 6.1), *Porter's competitive forces model* (Section 6.2), *Parson's approach* (Section 6.3), and the approach provided by *McFarlan/McKinney* (Section 6.4).

6.1 Nolan's Approach

Nolan's approach [59, 60] (cf. Fig. 18A) is based on three consecutive evaluation steps (cf. Fig. 17):

- ***Step 1***: First, the objectives of an organization are identified. Three objectives are of particular relevance: (1) to improve productivity (in order to reduce the time-to-market), (2) to strengthen the market position and competitive advantage of an organization, and (3) to improve the effectiveness of management functions. All identified enterprise objectives are subordinated to one of these three major goals.

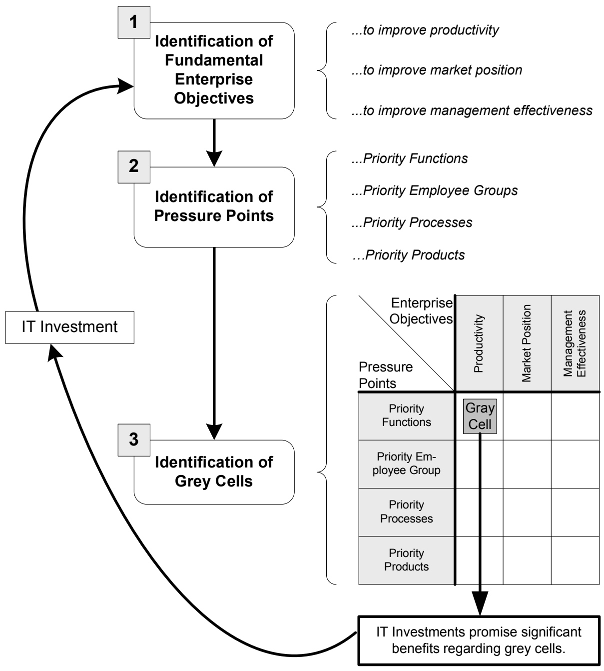

Figure 17. Applying the Approach of Nolan.

- ***Step 2***: Second, so called *pressure points* are derived. Each pressure point aggravates the achievement of one (or several) of the previously identified enterprise objectives. In other words, a pressure point represents a critical business object that exhibits non-optimal (i.e., improvable) business performance (independent on how business performance is measured). Such critical business objects can be single business functions (*priority functions*), user groups (*priority employee groups*), business processes (*priority processes*), or even entire products (*priority products*).

- ***Step 3***: In this third step, *gray cells* are identified. A gray cell describes those IT systems (e.g., an ERP system) that do not provide adequate support in the context of a specific pressure point (and that therewith hamper the achievement of the enterprise objectives). Grey cells are derived using a matrix with the pressure point as the first, and the fundamental enterprise objectives as the second dimension (cf. Fig. 17). Focusing on identified gray cells promises significant benefits regarding the achievement of enterprise objectives.

This approach is particularly suitable for the portfolio management of an organization, i.e., it helps to identify weak parts of an IT infrastructure and helps to guide new IT investment (by selecting an IT investment based on its suitability to address a gray cell). It can be also used to evaluate whether the introduction of IT is a reasonable investment.

6.2 Porter's Competitive Forces Model

Porter's *competitive forces model* [62] (cf. Fig. 18B) focuses on market position and competitive advantage. It is based on the analysis of five "competitive forces" which shape every industry and every market, and which determine the intensity of competition:

- ***Force 1***: *Entry of Competitors*. This force deals with the question how easy or difficult it is to enter a market (e.g., through market barriers).

- ***Force 2***: *Threat of Substitutes*. This force deals with the question how easy or difficult a product or service can be substituted by competing offers. A threat from substitutes will occur if there exist alternative products with lower prices and better performance parameters for the same purpose.

- ***Force 3***: *Power of Buyers*. This force deals with the position of buyers (and their pressure on margins).

- ***Force 4***: *Power of Suppliers*. This force deals with the questions how strong the position of suppliers is (which is likely to be high, for example, when a market is dominated by only a few large suppliers).

- ***Force 5***: *Competition among existing Market Players*. This force deals with the questions whether there is a competition between existing market players.

The objective of corporate strategy is to modify these competitive forces in a way that improves the market position of

Criteria	A: Nolan's Approach	B: Porter's Competitive Forces Model
I. Classification Criteria		
C-1: Evaluation Viewpoint		
Financial Viewpoint		
Work Performance Viewpoint		
Strategic Viewpoint	x	x
C-2: Decision Support	Particularly suitable for an organization's portfolio management	Focuses on market position and competitive advantage.
C-3: Evaluation Dimension		
Evaluation of Benefits	x	x
Evaluation of Costs		x
Evaluation of Risks		x
Evaluation of Work Performance	x	
C-4: Evaluation Scope		
ex-ante	x	x
ex-post		x
C-5: Evaluation Outcome		
Quantification | Absolute Measures		
Quantification | Relative Measures		
Visualization of Outcome		
Qualitative Conclusions	x	x
II. Evaluation Criteria		
E-1: Plausibility		
Interpretability of Evaluation Results	→	→
Transparency of Result Generation	→	↓
E-2: Objectiveness		
Degree of Objectiveness	↓	↓
E-3: Sensitivity		
Error-Proneness of Evaluations	↓	↓
Resistance against Manipulation	↓	↓
E-4: Practical Applicability		
Flexibility	→	↑
Efficiency (Effort) – Data Collection & Preparation – Availability	↓	→
Efficiency (Effort) – Data Collection & Preparation – Heterogeneity	↓	→
Efficiency (Effort) – Data Collection & Preparation – Data Quality	↓	→
Efficiency (Effort) – Overall Effort	↓	↑
Effectiveness – Comparability	↓	↓
Effectiveness – Correctness of Conclusions	↑	↑
E-5: Theoretical Foundation		
Degree of Formalization	↓	↓
E-6: Tool Support		
Simplicity of providing Tool Support	↓	→

Caption: x: supported o: optional ↑: positive ↓: negative →: neutral

Figure 18. The Approach of Nolan and Porter's Competitive Forces Model.

an organization. Thereby, one distinguishes between *physical* and *informational* activities (which improve market position based on their impact on the competitive forces). *Physical activities* embrace all activities that result in the creation or handling of a physical product (e.g., a car). *Informational activities*, by contrast, are based on experience knowledge, intuition and other intangible factors (e.g., the introduction of a new IT for automating the procurement process of an automotive manufacturer).

Generally, Porter's approach has been subject of much critique. *First*, in the economic sense, the model assumes a "perfect market". The more a market is regulated, the less meaningful insights can it deliver. *Second*, the model is particularly suitable for dealing with simple market structures. In complex market structures, however, the comprehensive description and analysis of all five forces tend to get difficult. *Third*, the model assumes static market structures (which is not the case today). *Fourth*, the model is based on the idea of competition. It assumes that organizations try to achieve competitive advantages over other market players, suppliers, and customers. With this focus, the model does not take into account strategic alliances, networked business constellations [6], or virtual enterprise-networks.

6.3 Parson's Approach

Parson's Approach [60] (cf. Fig. 19A) analyzes the strategic impact of IT along three levels: the *industry sector level* (also called *global level*), the *enterprise level*, and the *strategic level*. On the global level, IT investments influence the structure of entire industrial sectors, production environments, and markets. As an example consider the realization of cross-organizational IT solutions such as e-commerce marketplaces. On both the enterprise level and the strategic level, IT investments are analyzed with respect to their impact on the competitive forces.

Parson's approach aims at supporting managers in evaluating the potential impact of an IT investments on the market position of an organization. Like in the case of Porter's competitive forces model, it not clear whether Parson's approach can be used to derive really useful evaluations. In any case, Parson's approach adopts a very broad and holistic viewpoint.

6.4 Approach of McFarlan/McKinney

The approach provided by McFarlan/KcKinney [44, 60] (cf. Fig. 19B) utilizes a *strategic grid* for assessing the achievement of strategic enterprise objectives through IT investments. This strategic grid allows for conclusions regarding the IT landscape of an organization. Therefore, any potential IT investment is assigned to one of the four quadrants of the strategic grid (cf. Fig. 20):

- ***Low Current — Low Future Impact***: The IT investment has only little strategic relevance and only supports existing business processes.
- ***Low Current — High Future Impact***: The IT investment will have a major impact on future business models, i.e., it will be a key element of strategic planning.
- ***High Current — Low Future Impact***: The IT investment is important in terms of day-to-day operations,

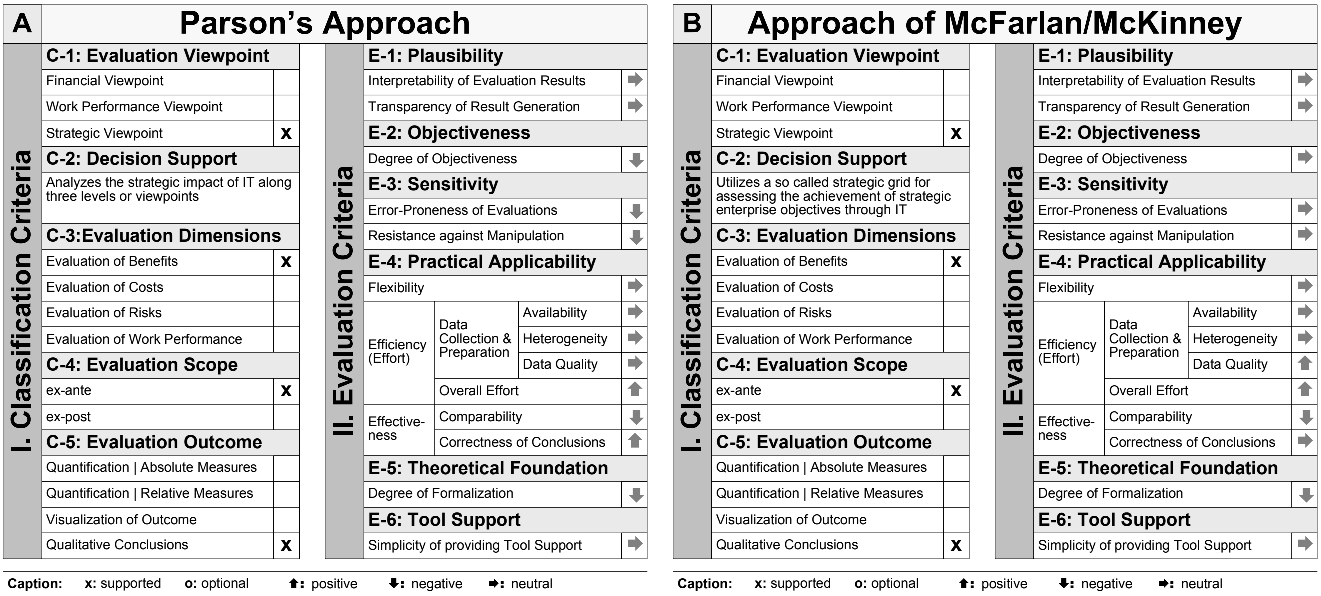

Figure 19. The Approach of Parsons and the Approach of McFarlan/McKinney.

but cannot be considered as fundamentally important. The key issue is maintaining existing IT solutions.

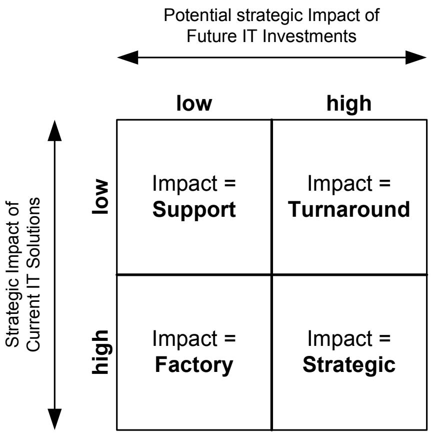

Figure 20. The Strategic Grid.

- ***High Current — High Future Impact***: The IT investment is a success factor both for the current and future strategy of the organization, i.e., the IT investment has strategic significance.

Like Nolan's approach, this approach is particularly to guide the portfolio management of an organization.

6.5 Real Option Theory

Real option theory applies *financial option theory* (e.g., the Black-Scholes option-pricing model) to IT investments. Thereby, a *financial option* is priced based on information which can modify the outcome of future investment decisions. A *real option*, in turn, is defined as the right but not the obligation to acquire the present value of the expected revenues by making an investment when the opportunity is available. It is based on five key components [7]: (i) value of asset, (ii) exercise or strike price, (iii) time to expiration, (iv) volatility, and (v) risk-free rate. A real option will have value only when there is uncertainty as to the possible outcomes of the initial investment. The higher the uncertainty of the potential cash flows the higher the value of the option. In other words, real options have value when an investment results in costs that cannot be recovered as well as if there is uncertainty on the ability to obtain cash flows. This makes counterintuitive sense, but the ability to obtain larger payouts increases the value of the opportunity as the option holder does not loose from the increased uncertainty if the project goes sour.

Generally, there are several kinds of options given the multiple outcomes in decision making. First, a *simple option* is defined as the ability to buy or sell an option at a defined price in one occasion at or before the expiration of the option. Second, *compounded options* can be used. The only difference of compounded options, when compared to simple options, is that when exercised a compounded option generates another option. Compounded options are more practical as they are used for staggered investment involving multiple decisions though the life cycle of a project. Third, *expansion options* include the right but not the obligation to expand the investment of a project. Fourth, *abandonment options* are the right to stop or postpone the project if the expected cash flows are below the salvage value.

Real option theory is applicable when there is a high degree of uncertainty, some managerial flexibility, and not all evaluation information available. Examples of using real option theory can be found, for example, in the context of software engineering [8, 16, 67].

7 The Big Picture

Today's policy makers usually rely on simple and static decision models as well as on intuition and experiences rather than on a profound analysis of an IT investment decision. Also, rules of thumb such as "invest to keep up with the technology" or "invest if the competitors have been successful" are often applied as decision basis. Often, there is also an asymmetric consideration of costs and benefits. For example, many financial calculations (cf. Section 4) overestimate benefits in the first years in order to constitute a positive ROI. Besides, many standard evaluation approaches are often not suitable to be used at early planning stages of IT investments. In fact, many projects (especially those which utilize innovative information technology) often have - despite their potential strategic importance - a negative economic valuation result at an early stage. This situation results in a high risk of false rejection. This means that enterprises with independently operating business units under the objective to maximize the equity of a company in short term have to overcome the problem not to routinely reject truly important IT investments based on the results of too simple evaluation techniques.

This survey shall help to better understand economic-driven IT evaluation approaches as well as their strengths and weaknesses. Fig. 21 shows the classification criteria and evaluation criteria of the 19 analyzed IT evaluation approaches at a glance. Note that all evaluations as represented in Fig. 21 have been derived based on a careful analysis of each evaluation approach.

8 Other Approaches

There are other approaches that address IT evaluation from a value-based perspective. Their goal is to develop fundamental knowledge and practical techniques to increase the value created over time by IT projects.

8.1 Value-based Software Engineering

Value-based Software Engineering (VBSE) integrates value considerations into software engineering principles and practices [11, 13]. Seven key "elements" constitute the conceptual foundations for VBSE [12, 14, 15]: benefits realization analysis, stakeholder value proposition elicitation and reconciliation, business case analysis, continuous risk and opportunity management, concurrent system and software engineering, value-based monitoring and control, and change as opportunity.

To be able to cover all relevant aspects of the life cycle of a software system various *value-based sub-models* are introduced. As an example consider the sub-model *value-based requirements reengineering* (VBRE), which includes principles and practices for identifying success-critical stakeholders of a system, for eliciting their value propositions with respect to the software system, and to reconcile these value propositions into a set of system objectives. The *value-based architecting* (VBA) sub-model, as second example, involves the reconciliation of the objectives of a software system with achievable architectural solutions. The *value-based design and development* (VBDD) sub-model, as a last example, involves techniques for ensuring that the objectives and value considerations of a software system are inherited by the design and development of the software.

Altogether, VBSE is an approach that combines existing software techniques and management approaches with a value-oriented focus. Due to the enormous number of integrated concepts VBSE is still in a conceptual stage. In particular, there exist no VBSE best practices. Consequently, it is hardly possible to transform VBSE into practice.

8.2 The e3-value Framework

The *e3-value Framework* is a multi-viewpoint requirements engineering method that is based on analyzing e-commerce initiatives through stakeholder-based viewpoints [5, 30, 31, 32]. Its goal is to derive and analyze multi-enterprise relationships, business cases and requirements.

The framework defines three evaluation perspectives each of them representing an evaluation baseline to evaluate stakeholder's interests and derive suitable requirements. The *business value viewpoint* focuses on the way of economic value creation, distribution and consumption in multi-actor networks. It enables setting up a prediction of revenues and expenses, based on exchanges of valuable goods and services between multiple actors. The *business process viewpoint* focuses on a way to put the value viewpoint into operation in terms of business processes. It examines operational fulfillment of business processes. The *information system viewpoint* focuses on the information systems that enable and support processes.

8.3 Value-based IT Alignment

The VITAL framework [1] (***V**alue-based **IT Al**ignment*) investigates the problem of aligning IT services to business requirements [75]. It builds upon work in value-based re-

The Big Picture

Economic-driven Evaluation Approaches — **O v e r v i e w**

Criteria	Return On Investment (ROI)	Payback Period	Accounting Rate of Return	Breakeven Analysis	Net Present Value (NPV)	Internal Rate of Return (IRR)	Zero Base Budgeting	Cost Effectiveness Analysis	Total Cost of Ownership (TCO)	Target Costing	Times Savings Times Salary Model	Hedonic Wage Model	Activity-based Costing	Business Process Intelligence	Nolan's Approach	Porter's Competitive Forces Model	Parson's Approach	Approach of McFarlan and McKenney	Real Option Theory
I. Classification Criteria																			
Evaluation Viewpoint																			
Financial Viewpoint	X	X	X	X	X	X	X	X	X	X			O	O					X
Work Performance Viewpoint											X	X	X	X					
Strategic Viewpoint															X	X	X	X	X
Evaluation Dimension																			
Evaluation of Benefits	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X
Evaluation of Costs	X	X	X	X	X	X	X	X	X	X			X	X		X			X
Evaluation of Risks	O	O	O	O	O	O										X			
Evaluation of Work Performance												X		X	X				
Evaluation Scope																			
ex-ante	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ex-post	X	X	X	X									X	X		X			
Evaluation Outcome																			
Quantification | Absolute Measures	X	X		X	X		X		X		X	X	X	X					X
Quantification | Relative Measures			X			X								X					x
Visualization of Outcome		O		O			X		X			X	X	X					X
Qualitative Conclusions								X		X					X	X	X	X	X
II. Evaluation Criteria																			
Plausibility																			
Interpretability of Evaluation Results	→	↑	→	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	→	→	→	→	→
Transparency of Result Generation	↑	↑	↑	↑	↑	↑	↑	→	↑	→	↑	↑	↑	↑	→	↓	→	→	→
Objectiveness																			
Degree of Objectiveness	↑	→	↑	→	→	→	↑	→	↑	→	↑	↑	↑	↑	↓	↓	↓	→	→
Sensitivity																			
Error-Proneness of Evaluations	→	→	→	→	↓	→	↑	→	↑	→	↓	→	↓	↑	↓	↓	↓	→	→
Resistance against Manipulation	→	↓	→	↓	↓	→	→	→	→	→	→	→	→	→	↓	↓	↓	→	→
Practical Applicability																			
Flexibility	↑	→	↑	→	→	→	↑	↑	↑	↑	↑	↑	↑	↑	→	↑	→	→	↑
Efficiency (Effort) – Data Collection & Preparation – Availability	→	→	→	→	→	→	→	↓	→	↓	→	→	→	↑	↓	→	→	→	→
Efficiency (Effort) – Data Collection & Preparation – Heterogeneity	→	→	→	→	→	→	↑	↓	↑	↓	↑	↑	↑	→	↓	→	→	→	→
Efficiency (Effort) – Data Collection & Preparation – Data Quality	→	→	→	→	→	→	→	↓	→	↓	↓	↓	↓	↑	↓	→	→	↑	↑
Efficiency (Effort) – Overall Effort	↑	↑	↑	↑	↑	↑	→	↓	→	↓	↑	→	↑	→	↓	↑	↑	↑	↑
Effective-ness – Comparability	↑	↑	↑	↑	→	↑	→	↑	→	↑	↑	↑	↑	↑	↓	↓	↓	↓	→
Effective-ness – Correctness of Conclusions	→	→	→	→	→	→	↑	↑	↑	↑	→	→	→	→	↑	↑	↑	→	→
Theoretical Foundation																			
Degree of Formalization	↑	↑	↑	↑	↑	↑	→	→	→	→	↑	↑	→	↑	↓	↓	↓	↓	↑
Tool Support																			
Simplicity of providing Tool Support	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	→	↑	↓	→	→	→	→

Caption: **x:** supported **o:** optional **↑:** positive **↓:** negative **→:** neutral

Figure 21. IT Evaluation Approaches: The Big Picture.

quirements engineering [5] (cf. Section 8.2) and ICT architecture design [78, 80].

With the advent of networked business constellations [58, 82], this problem even gets a new dimension. In such networks, there is not a single decision point about IT support and different actors in the network may have conflicting requirements. Each actor has the goal to act in a profitable way. In order to fulfill this requirement, the *income statement* [65] (also called *profit* [27] or *net value flow* [32]) is typically considered.

The VITAL framework addresses important issues that have to be addressed when evaluating IT from a value-based perspective. However, its specific focus on networked business constellations and cross-organizational IT environments can make it difficult to apply it to use results of the VITAL project in the context of IT evaluation.

9. Illustrating Example

Consider a phone company named *TwenteConnect* that serves a regional market. So far, the company provides only fixed land-line services and does not sell any hardware components such as cell phones to their customers. Now, TwenteConnect wants to expand to the area of mobile phone services, again in the same region. However, before starting to target customers, a test phase with corporate clients is scheduled. In this test phase, the local police and the staff of the local hospital shall be provided with mobile phone connections (including mobile phones).

As TwenteConnect does not produce the necessary hardware (i.e., mobile phones), it collaborates with a large manufacturer of mobile phones. As a result of this collaboration, TwenteConnect (i) buys the mobile phones at markdown prices, (ii) bundles them with diverse communication services (e.g., voice mail, wireless web access, short message service), and (iii) offers these bundles (as a *value proposition*) to corporate customers.

It shall be evaluated whether the test phase promises a (positive) *net income* (or positive *net value flow*) for TwenteConnect. A respective evaluation has to take into account expenses, revenues, and eventually subsequent investments and is needed prior to the actual decision. Therefore, we take a financial viewpoint (cf. Section 3.2, Criterion C-1).

Using Static Approaches. We assume that the local hospital has a need of 20 mobile phone bundles, while the police has a need of 80 ones (resulting in a total amount of 100). For each mobile phone TwenteConnect has to pay 40 Dollars to the mobile phone producer (100*40$=4.000$), but sells it for 1 Dollar to its corporate clients (100*1$=100$). Further, *TwenteConnect* sells the connectivity as a monthly mobile phone flatrate for 15 Dollars (100*15$=1.500$/month). If we consider the time-period of one year we assume to get a net income of 14.100$ (-4.000$+18.100$=14.100$). Note that the second year will differ in such a way that the income will be even 18.000$, because everybody from the police and hospital already has a mobile phone and we assume two years of average usage of such hardware.

So far, our calculations considered expenses and revenues, but we also need to consider investments at the information system level. For instance, if we need to buy a software piece for realizing the business idea, we need to know whether it is worth investing money for specific software. Assume that the price for the missing piece of software is 3525$. Considering another static evaluation method, namely the previously described *payback period*, we can calculate that the time required to recoup the investment is just three months.

Using Dynamic Approaches. Both the *net value flow* and the *payback period* are straightforward approaches, but do not address the time value of money. If the time period we are concerned with is one year, each 1$ we get in one year will be less valuable than 1$, which we would have now. We could put the money in a bank and get in one year some interest on it. Considering this fact, we need to discount the net value flows. For doing so Gordijn [32] suggests the so-called *discounted net present cash flow* (DNPC) technique, which finds its origins in the previously described NPV (cf. Section 3.2.2).

Take the first time-period were we already calculated an undiscounted net value flow of 14.100$. By discounting it, let's say with an interest rate of 5%, we have a value at the start of the first period of just 13.428,57$. If we discount the net value flow for the second year ($18.000/1.05^2$), the value will at the start of the first time-period be just 16.326.53$, instead of the previously calculated net value flow of 18.000$. We already drew up how to use the payback period method with respect to investments. The DNPC approach allows to include expenses for investments. In our case we had to make an investment for a software piece amounting to 3525$, for realizing the business case.

In terms of the DNPC this is an *upfront investment*, where a special time-period 0 has to be introduced.

Period	Revenues	Expenses	Investm.	Total	DNPC
0			3.525	-3.525	-3.525
1	18.100	4.000		14.100	13.428,57
2	18.000			18.000	16.326,53
Total				**28.575**	**26.230,10**

Table 2. Net Value Flow versus DNPC.

Table 2 compares the (undiscounted) net value flow calculations with the DNPC for the two mentioned years (period 1 and 2) with an upfront investment period 0 to include the investment.

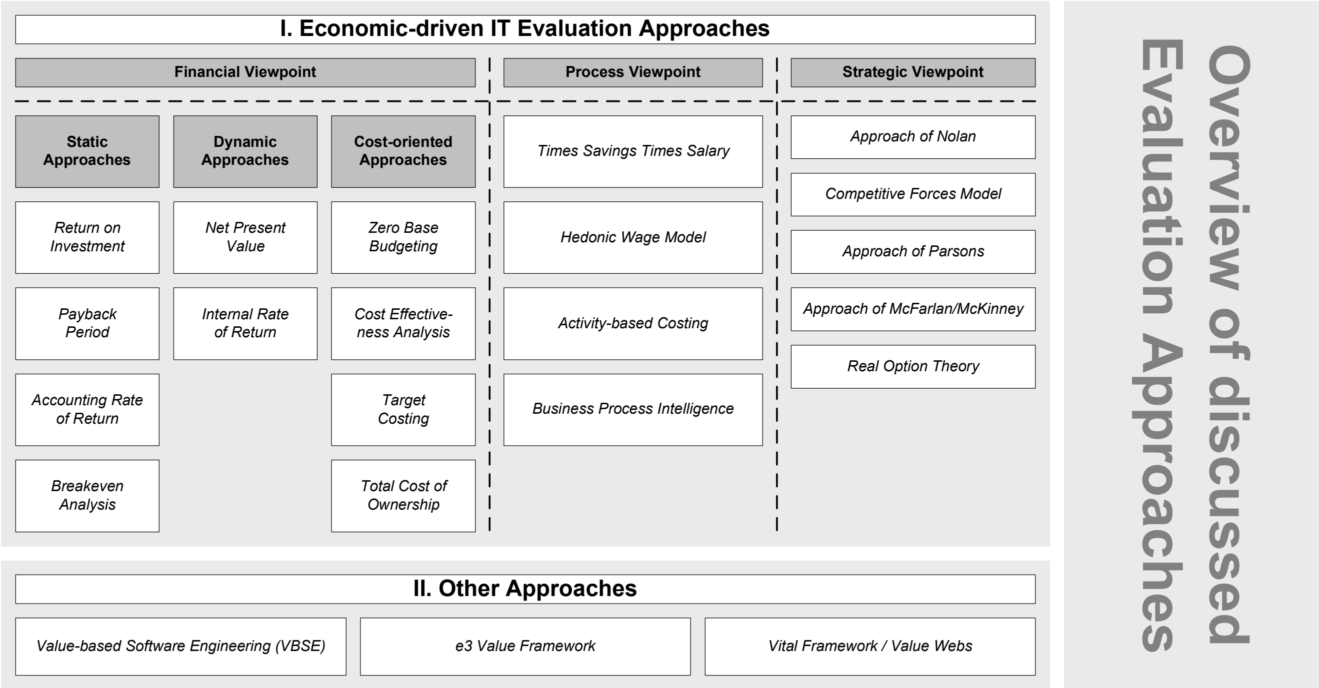

Figure 22. Overview of discussed Approaches.

10 Summary

Economic-driven evaluations have become an important instrument in the management of IT projects. Numerous approaches have been developed to quantify the costs of an investment, its assumed profit, to evaluate its impact on business process performance, or to analyze the role of IT toward the achievement of enterprise objectives. This survey has discussed and compared approaches for evaluating IT from an economic-driven perspective. Our comparison has been based on a multi-criteria framework distinguishing between classification criteria and evaluation criteria. Finally, we have given an example of a typical economic-driven evaluation using financial business ratios.

This research has been conducted in the EcoPOST[4] project [51, 54, 55, 56, 57]. In this project we are developing a framework for modeling and investigating the complex interplay between the numerous technological, organizational and project-driven cost and impact factors which arise in the context of process-aware information systems [26] (and which do only partly exist in projects developing data- or function-centered information systems).

[4] **Eco**nomic-driven Evaluation of **P**rocess-**O**riented **S**oftware **T**echnologies: http://is.ewi.utwente.nl/research/business_process_management/

References

[1] *Value-based IT ALignment (VITAL), University of Twente & Free University of Amsterdam*. Project Homepage: http//www.vital-project.org/, 2006.

[2] M. Amberg and M. Hirschmeier. *Reframing of Economic (e) Valuations for Innovative Technologies*. Proc. 7th Conf. on Synergetics, Cybernetics and Informatics, 2003.

[3] J. L. Andresen. *A Framework for Selecting an IT Evaluation Method - In the Context of Construction*. PhD Thesis, Technical University of Denmark, Lyngby, Denmark, 2001.

[4] Y. L. Antonucci. *Using Workflow Technologies to improve Organizational Competitiveness*. Int'l. Journal of Management, 14(1), pp.117-126, 1997.

[5] Z. Baida, H. de Bruin, and J. Gordijin. *e-Business Cases Assessment: From Business Value to System Feasibility*. Int'l. J. of Web Engin. & Technology, 1(1), pp.127-144, 2003.

[6] J. Y. Bakos and B. R. Nault. *Ownership and Investment in Electronic Networks*. Information Systems Research, 8(4), pp.321-341, 1997.

[7] M. Benaroch. *Managing Information Technology Investment Risk: A Real Options Perspective*. Journal of Management Information Systems, 19(2), pp.43-84, 2002.

[8] M. Benaroch and R. J. Kaufman. *A Case Study for Using Real Options Pricing Analysis to Evaluate Information Technology Project Investments*. Information Systems Research, 10(1), pp.70-86, 1999.

[9] R. Bobrik, T. Bauer, and M. Reichert. *Proviado - Personalized and Configurable Visualizations of Business Processes*. Proc. EC-Web 2006, pp.61-71, 2006.

[10] R. Bobrik, M. Reichert, and T. Bauer. *Requirements for the Visualization of System-Spanning Business Processes*. Proc. 1st Int'l. Workshop on Business Process Monitoring and Performance Management (BPMPM '05), Copenhagen, Denmark, 2005.

[11] B. Boehm. *Software Engineering Economics*. 1981.
[12] B. Boehm. *Value-Based Software Engineering*. ACM SIGSOFT Software Engineering Notes, 28(2), pp.1-12, 2003.
[13] B. Boehm, C. Abts, A. W. Brown, S. Chulani, B. K. Clark, E. Horowitz, R. Madachy, D. Reifer, and B. Steece. *Software Cost Estimation with Cocomo 2*. Prentice Hall, 2000.
[14] B. Boehm and L. G. Huang. *Value-Based Software Engineering - A Case Study*. IEEE Computer, 36(3), pp.33-41, 2003.
[15] B. Boehm and L. G. Huang. *Value-Based Software Engineering: Reinventing "Earned Value" Monitoring and Control*. Software Engineering Notes, 28(2), pp.29-36, 2003.
[16] B. Boehm and K. Sullivan. *Software Economics: A Roadmap*. Proc. 22nd Int'l. Conf. on Software Engineering, pp.319-343, 2000.
[17] D. F. Boyd and H. S. Krasnow. *Economic Evaluations of Management Information Systems*. IBM Systems Journal, 2(1), pp.2-23, 1963.
[18] E. Brynjolfsson. *The Productivity Paradox of Information Technology*. Comm. of the ACM, 36(12), pp.66-77, 1993.
[19] N. G. Carr. *IT doesn't Matter*. Harvard Business Review (HBR), 5, 2003.
[20] N. G. Carr. *Does IT matter?* Harvard Business Press, 2004.
[21] F. Casati, U. Dayal, M. Sayal, and M.-C. Shan. *Business Process Intelligence*. HP Technical Report, 2002.
[22] J. Chang. *Envisioning the Process-Centric Enterprise*. eai Journal, August 2002, pp.30-33, 2002.
[23] E. K. Clemons. *Evaluation of Strategic Investments in Information Technology*. Communications of the ACM, 34(1), pp.22-36, 1991.
[24] S. Cronholm and G. Goldkuhl. *Strategies for Information Systems Evaluation - Six Generic Types*. Electronic Journal of Information Systems Evaluation (EJISE), 6(2), 2003.
[25] T. DeMarco. *Controlling Software Projects: Management, Measurement and Estimation*. Yourdon Press, 1983.
[26] M. Dumas, W. M. P. van der Aalst, and A. H. ter Hofstede (Eds.). *Process-aware Information Systems: Bridging People and Software through Process Technology*. Wiley, 2005.
[27] E. O. Edwards, P. W. Bell, L. Todd Johnson, and J. H. Jones. *Accounting for Economic Events*. Scholar Books Co., 1979.
[28] J. Gebauer and F. Schober. *Information System Flexibility and the Cost Efficiency of Business Processes*. Journal of the Association for Information Systems, 7(3), pp.122-147, 2006.
[29] K. H. Goh and R. J. Kauffman. *Towards a Theory of Value Latency for IT Investments*. Proc. 38th Hawaii Int'l. Conf. on System Sciences (HICSS '05), Big Island, Hawaii, 2005.
[30] J. Gordijn. *Value-based Requirements Engineering*. PhD Thesis, Free University of Amsterdam, 2002.
[31] J. Gordijn and H. Akkermans. *Designing and Evaluating E-Business Models*. Intelligent Systems, 16(4),pp.11-17, 2001.
[32] J. Gordijn and H. Akkermans. *Value-based Requirements Engineering: Exploring innovative E-commerce Ideas*. Int'l. J. of Requirements Engineering, 8, pp.114-134, 2003.
[33] D. Grigori, F. Casati, M. Castellanos, U. Dayal, M. Sayal, and M. Shan. *Business Process Intelligence*. Computers in Industry, 53(3), pp.321-343, 2004.
[34] C. W. Günther, S. Rinderle, M. Reichert, and W. M. P. van der Aalst. *Change Mining in Adaptive Process Management Systems*. Proc. Int'l. Conf. on Cooperative Information Systems (CoopIS '06), pp.309-326, 2006.
[35] J. Hares and D. Royle. *Measuring the Value of Information Technology*. Wiley, 1994.
[36] P. Hawking, A. Stein, and S. Foster. *Revisiting ERP Systems: Benefit Realization*. Proc. 37nd Hawaii Int'l. Conf. on System Sciences (HICSS '04), Big Island, Hawaii, 2004.
[37] S. Horwitz. *The Economic Benefits of BPM*. eai Journal, June 2002, pp.37-39, 2002.
[38] J. Adams and L. Juleff. *Managerial Economics for Decision Making*. Palgrave Macmillan, 2003.
[39] L. Jin, F. Casati, and A. van Moorsel. *Design of A Business Process Analyzer for Business Process Management*. Proc. Int'l. Symposium on Information Systems and Engineering, San Diego, California, 2002.
[40] P. S. Katsma. *Business Function Support*. Pearson, 2004.
[41] G. Lamla. *Investigation, Comparison and Evaluation of Approaches for Measuring Business Process Performance (in German)*. Master Thesis, University of Ulm, Germany, 2005.
[42] J. H. Lim, V. J. Richardson, and T. L. Roberts. *Information Technology Investment and Firm Performance: A Meta-Analysis*. Proc. 37th Hawaii Int'l. Conf. on System Sciences (HICSS '04), Big Island, Hawaii, 2004.
[43] N. Lofts. *Process Visualization*. John Wiley, 2002.
[44] F. W. McFarlan and I. L. McKenney. *Corporate Information Systems Management*. Richard D. Irwin Inc., 1983.
[45] L. Meineke. *Wirtschaftlichkeitsanalysen - Basis zur Durchfuehrung von IT-Projekten*. IT Management, Volume 12, pp.12-17, 2003.
[46] F. Melchert and R. Winter. *The Enabling Role of Information Technology for Business Performance Management: Decision Support in an Uncertain and Complex World*. Proc. 2004 IFIP Int'l. Conf. on Decision Support Systems (DSS '04), pp.535-546, 2004.
[47] F. Melchert, R. Winter, and M. Klesse. *Aligning Process Automation and Business Intelligence to support Corporate Performance Management*. Proc. 2004 Americas Conf. on Information Systems (AMCIS '04), pp.53-63, 2004.
[48] M. W. Mende, L. Brecht, and H. Oesterle. *Evaluating existing Information Systems from a Business Process Perspective*. Proc. 1994 Computer Personnel Research Conference on Reinventing IS, pp.289-296, Alexandria, Virginia, 1994.
[49] K. E. Murphy and S. J. Simon. *Using Cost Benefit Analysis for Enterprise Resource Planning Project Evaluation: A Case for including Intangibles*. Proc. 34th Hawaii Int'l. Conf. on System Sciences (HICSS '01), 2001.
[50] B. Mutschler and M. Reichert. *Business Process Intelligence*. EMISA Forum, 26(1), pp.27-31, 2006.
[51] B. Mutschler and M. Reichert. *A Survey on Evaluation Factors for Business Process Management Technology*. Technical Report TR-CTIT-06-63, Centre for Telematics and Information (CTIT), University of Twente, 2006.
[52] B. Mutschler, M. Reichert, and J. Bumiller. *An Approach to quantify the Costs of Business Process Intelligence*. Proc. Int'l. Workshop on Enterprise Modeling and Information Systems Architectures (EMISA '05), LNI P-75, pp.152-165, Klagenfurt, Austria, 2005.

[53] B. Mutschler, M. Reichert, and J. Bumiller. *Towards an Evaluation Framework for Business Process Integration and Management*. 2nd Int'l. Workshop on Interoperability Research for Networked Enterprises Applications and Software (INTEROP), Enschede, The Netherlands, 2005.

[54] B. Mutschler, M. Reichert, and J. Bumiller. *An Approach for Evaluating Workflow Management Systems from a Value-Based Perspective*. Proc. 10th IEEE Conf. on Enterprise Computing (EDOC 2006), pp.477-482, Hong Kong, China, 2006.

[55] B. Mutschler, M. Reichert, and J. Bumiller. *Designing an Economic-driven Evaluation Framework for Process-oriented Software Technologies*. Proc. 28th Int'l. Conf. on Software Engineering (ICSE '06), pp.885-888, Shanghai, China, 2006.

[56] B. Mutschler, M. Reichert, and J. Bumiller. *Why Process-Orientation is Scarce: An Empirical Study of Process-oriented Information Systems in the Automotive Industry*. Proc. 10th IEEE Conf. on Enterprise Computing (EDOC 2006), pp.433-438, Hong Kong, China, 2006.

[57] B. Mutschler, M. Reichert, and S. Rinderle. *Analyzing the Dynamic Cost Factors of Process-aware Information Systems: A Model-based Approach*. Proc. 13th CAiSE, 2007 [accepted for publication].

[58] N. Zarvić and M. Daneva. Challenges and Solutions in Planning Information Systems for Networked Value Constellations. In M. Weske and M. Nüttgens, editor, *Proc. EMISA 2006 - Methoden, Konzepte und Technologien für die Entwicklung von dienstbasierten Informationssystemen*, volume P-95 of *LNI - Lecture Notes in Informatics*, pages 119–131, Hamburg, 2006.

[59] D. P. Norton. *Stage by Stage - Letter to Management*. The Economics of Computing in the Advanced Stages, 1981.

[60] T. Pietsch. *Bewertung von Informations- und Kommunikationssystemen : Ein Vergleich betriebswirtschaftlicher Verfahren*. ESV (Erich Schmidt Verlag), 2003.

[61] T. Pisello. *IT Value Chain Management - Maximizing the ROI from IT Investments: Performance Metrics and Management Methodologies Every IT Stakeholder Should Know*. Alinean, LLC, available at: www.alinean.com, 2003.

[62] M. E. Porter. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. Free Press, 1998.

[63] L. Putnam and W. Meyers. *Measures for Excellence: Reliable Software on Time, Within Budget*. Yourdon Press Computing Series, 1991.

[64] R. L. Daft. *Management*. Dryden Press, 1997.

[65] R. N. Anthony and J. S. Reece. *Accounting: Text and Cases*. Irwin, 1979.

[66] D. J. Reifer. *Making the Software Business Case - Improvement by the Numbers*. Addison-Wesley, 2001.

[67] D. J. Reifer. *Use of Real Options Theory to Value Software Trade Secrets*. Proc. 2nd Int'l. Workshop on on Economics-Driven Software Engineering Research, 2003.

[68] S. Rinderle, R. Bobrik, M. Reichert, and T. Bauer. *Business Process Visualization - Use Cases, Challenges, Solutions*. Proc. Int'l. Conf. on Enterprise Information Systems (ICEIS '06), pp.204-211, 2006.

[69] S. Rinderle, B. Weber, M. Reichert, and W. Wild. *Integrating Process Learning and Process Evolution - A Semantics Based Approach*. Proc. Int'l. Conf. on Business Process Management (BPM '05), pp.252-267, 2005.

[70] P. G. Sassone. *Cost-Benefit Methodology for Office Systems*. ACM Transactions on Office Information Systems, 5(3), pp.273-289, 1987.

[71] P. G. Sassone. *Cost Benefit Analysis of Information Systems: A Survey of Methodologies*. Proc. Int'l. Conf. on Supporting Group Work (GROUP '88), pp.73-83, Palo Alto, 1988.

[72] M. Sayal, F. Casati, U. Dayal, and M.-C. Shan. *Business Process Cockpit*. Proc. 28th Int'l. Conf. on Very Large Databases (VLDB '02), pp.880-883, Hong Kong, China, 2002.

[73] J. K. Shank and J. Fisher. *Target Costing as a Strategic Tool*. MIT Sloan Management Review, 41(1), pp.73-82, 1999.

[74] H. Smith and P. Fingar. *IT doesn't matter - Business Processes Do*. Meghan Kiffer Press, 2003.

[75] P. P. Tallon and K. L. Kraemer. *A Process-oriented Alignment of Information Systems and Business Strategy: Implications for IT Business Value*. Proc. 4th Americas Conf. on Information Systems (AIS), 1998.

[76] M. Tegstam and J. Weiner. *Evaluating Costs and Benefits when Implementing an Information System - A PDM System at Autoliv Inc*. Masters Thesis, School of Economics and Commercial Law, Goeteborg University, 1999.

[77] W. M. P. van der Aalst and A. J. M. M. Weijters. *Process Mining - A Research Agenda*. Computers in Industry, 53(3), pp.231-244, 2004.

[78] P. van Eck, H. Blanken, and R. Wieringa. *Project GRAAL - Towards Operational Architecture Alignment*. Int'l. J. of Cooperative Information Systems, 13(3), pp.235-255, 2004.

[79] B. Weber. *Aktuelles Schlagwort: Business Process Life Cycle*. EMISA Forum, Volume 1, 2007.

[80] R. J. Wieringa, P. van Eck, and H. Blanken. *Architecture Alignment in a Large Government Organization: A Case Study*. Proc. 16th Int'l. Conf. on Advanced Information Systems Engineering (CAiSE '04), Forum, Riga, Latvia, 2004.

[81] J. A. Zachman. *A Framework for Information Systems Architecture*. IBM Systems Journal, 26(3), pp. 276-292, 1987.

[82] N. Zarvić, M. Daneva, and R. Wieringa. *Value-Based Requirements Engineering for Value Webs*. The 13th Working Conference on Requirements Engineering: Foundation for Software Quality (REFSQ '07), 2007 [to appear].

[83] R. W. Zmud. *Information Systems in Organisations*. Scott Foresman, 1983.

[84] M. zur Muehlen. *Workflow-based Process Controlling - Foundation, Design and Application of Workflow-driven Process Information Systems*. Logos Verlag Berlin, 2004.