



University of Augsburg  
Prof. Dr. Hans Ulrich Buhl  
Research Center  
Finance & Information Management  
Department of Information Systems  
Engineering & Financial Management

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Discussion Paper WI-349

## **An EA-Based Approach to Valuate Enterprise Transformation: The Case of IS Investments Enabling On Demand Integration of Service Providers**

by

Dorsch Christoph, Häckel Björn

December 2011

in: Proceedings of the 20th European Conference on Information Systems,  
Barcelona, Spain, June 2012, Paper 129.



The international Journal of  
WIRTSCHAFTSINFORMATIK

# **AN EA-BASED APPROACH TO VALUATE ENTERPRISE TRANSFORMATION: THE CASE OF IS INVESTMENTS ENABLING ON DEMAND INTEGRATION OF SERVICE PROVIDERS**

Dorsch, Christoph, FIM Research Center, University of Augsburg, Universitaetsstr. 12, 86159 Augsburg, Germany, christoph.dorsch@wiwi.uni-augsburg.de

Häckel, Björn, FIM Research Center, University of Augsburg, Universitaetsstr. 12, 86159 Augsburg, Germany, bjoern.haeckel@wiwi.uni-augsburg.de

## **Abstract**

*Determining the value contribution of IS investments is a crucial task to support conscious decisions, e.g. about the scope or for or against the implementation of these investments. IS investments transform an enterprise not only in its IS related architecture, but often enable enhancements within the business related architecture. Valuating IS investments from an integral point of view therefore means to measure the value contribution to all affected artifacts of an enterprise.*

*Enterprise architecture (EA) used as a coordinative framework to value enterprise transformation may help to support this goal. We propose a valuation approach for IS investments based on EA offering two advantages: As through EA all artifacts of and their relationships within an enterprise are known, the impact of IS investments on all architectural layers can be identified and attributed to the IS investments as an integral value. Furthermore EA provides (detailed) models of all artifacts changed. These models can be used to support the valuation of the IS investments' impact on all affected artifacts.*

*To demonstrate how this valuation approach can be tailored for valuating a concrete IS investment, we apply it to the exemplary case of valuating an IS investment enabling the on demand integration of service providers. Therefore we model the enabled enhancements of this IS investment on the business and business process architecture, relating on the basic optimization problem of capacity planning within a certain business process. A case study of the payment transaction process of a banking transactions provider finally shows the applicability of the valuation approach.*

*Keywords: IS Enabled Enterprise Transformation, Valuation Approach, Enterprise Architecture, Integral View of IS and Business Artifacts, Decision Model.*

# 1 Introduction

The concept of a value-based management claims the alignment of all business activities on all hierarchy levels with the objective of maximizing the enterprise value (Rappaport, 1986). Therefore, an enterprise must be able to quantify the value contribution of individual business activities and assets as well as of their interactions (Buhl et al., 2011). This holds true for IS investments, as research within the last decade agreed on the value-adding characteristic of IS investments (Brynjolfsson and Hitt, 2003; Melville et al., 2004). Especially IS investments gaining competitive advantages and so-called rule changing IS innovation investments are often accompanied by a radical transformation of the enterprise (Craig and Tinaikar, 2006). This implies not only fundamental changes in an enterprise's IS architecture but also a transformation of an enterprise's business and business process architecture. As such IS investments usually come along with high initial investment costs, an enterprise has to implement adequate methods for the a priori valuation of IS investments in order to ensure conscious decisions with respect to a value-based management. According to the concept of a value-based management the value contribution of an IS investment should be defined as its quantitative, financial impact on the enterprise measured on the basis of net cash flows (Walter and Spitta, 2004). However, this is far from trivial. In particular, anticipating the economic benefits coming along with a new IS investment is a tremendous challenge (Bannister and Remenyi, 2000; Chan, 2000). This holds true even more for IS investments transforming the whole enterprise, not only its IS related, but also its business related architecture. For determining the value contribution of such IS investments, their impact on all layers of the enterprise architecture (EA) have to be taken into account (Kohli and Grover, 2008). In particular, the cash flow effects arising on the business and business process layers have to be considered and attributed to the inducing IS investment to determine its integral value.

Against this background we propose a valuation approach for IS investments considering the impacts on the business and business process architecture. Our valuation approach thereby is closely linked to the concept of EA models which describe different layers of IS and business related artifacts as well as their interplay (e. g. Aier et al., 2009; Winter and Fischer, 2007). Considering all layers of EA, the basic idea of the valuation approach is to measure the cash flow delta induced by an IS investment on the business related layers. Based on that we can determine the value contribution of an IS investment by attributing this cash flow delta to the respective IS investment.

To be applicable to a specific IS investment valuation problem this valuation approach furthermore has to be substantiated. In particular, it has to be tailored based on the characteristics of the IS investment considered, the economic impacts of this IS investment on the different layers of EA as well as all artifacts affected. For a demonstration how this can be done, we introduce the case of IS investments enabling the on demand integration of external service providers. These investments are typical examples for IS investments transforming not only IS related architectural layers of EA but furthermore enabling enhancements within the business architecture (e. g. through expanded value networks) and the business process architecture (e. g. through loosely coupled inter-organizational processes) and therefore transforming the whole enterprise.

On demand integration thereby is enabled by new technologies and concepts (e. g. the service-oriented design of IS suitable for the integration of web-services as well as corresponding description languages (WSDL) or sophisticated standards for data description and exchange like XML or EDIFACT) that lead to faster and less expensive integration projects. Even an on demand integration of external service providers meanwhile is a feasible alternative, meaning that new business relations can be established (nearly) without any loss of time by building up links fast and cheap. Following previous publications examining the effects of on demand integration of service providers on a corresponding business process (Braunwarth and Ullrich, 2010; Dorsch and Häckel, 2012), the enhancement of this IS investment on business process architecture arises, as on demand integration may allow routing of excessive demand to external service providers. Regarding the capacity planning problem associated with this business process, the on demand integration capability mitigates the risk

of choosing an inappropriate level of capacity (e.g. IT capacity, personnel capacity) and with that reduces the costs going along with an inappropriate level of assigned capacity (e.g. idle costs, waiting costs due to the violation of service level agreements) significantly.

Such IS investments in on demand capability reflect a typical case addressed with our valuation approach: Coming along with high initial costs they usually lead to considerable changes on business and business process layers. As the resulting future cash flows are not traceable within the IS related layers, one has to take all affected layers of the EA into account within IS investment valuation.

Summarizing, our research questions (RQ) structuring the remainder of this paper are the following:

- RQ 1: How can IS investments transforming the enterprise as a whole be valued properly?
- RQ 2: How can the valuation approach be tailored for the case of IS investments enabling on demand integration of service providers?

## 2 EA-based Approach to Valuate Enterprise Transformation

Before answering the first research question by presenting the valuation approach, we are discussing the related work to point out the research gap addressed with our paper.

### 2.1 Related Work

The existing theoretical literature on IS investment valuation usually starts from the premise that the financial impact of IS investments is clearly measurable and attributable. Thus, the questions on which layer of the EA model cash flows induced by a new IS investment arise and how to attribute them to the respective IS investment is not addressed. Instead the cash flows (or at least their stochastic distribution) resulting from a new IS investment are assumed to be already “known”. To name but a few Renkema and Berghout (1997), Sylla and Wen (2002) or Walter and Spitta (2004) address approaches to value a single IT investment and their suitability to determine the value of a single IT investment, but do not explicitly consider the impacts of IS investments on the different layers of the EA model. Furthermore there exist numerous articles like Benaroch et al. (2007), Dewan and Ren (2007), Dewan et al. (2007) and Verhoef (2005) that focus on the consideration of risk within IS investment valuation. However, these papers mostly abstract from interdependencies between the layers of the EA model concentrating instead on specific risks associated with IS investments (e.g. highly volatile cash flows), too. The same holds true for papers addressing stochastic interdependencies between various IS investments or within the IS investment portfolio like e.g. Fogelström et al. (2010), Jeffery and Leliveld (2004), Oh et al. (2007) or Reyck et al. (2005).

Therefore, despite the considerable amount of IS investment literature one can state that quantitative valuation approaches explicitly considering the impacts of IS investments on different EA layers necessary to gain an integral view, are still missing. Introducing our EA-based valuation approach we are aiming to contribute to the closure of this research gap.

### 2.2 Valuation Approach

There are two main challenges connected to the valuation of IS investments: They often affect not only the IS related architecture, but also the business related architecture of an enterprise. Because of this, all changes on all architectural layers have to be considered when determining an appropriate value for an IS investment. Furthermore, the economic benefits of these changes are difficult to capture and have to be attributed to the specific IS investment inducing this particular changes.

This is where EA can help as it connects IS related with business related artifacts (Bradley et al., 2011). Organized on different layers (see left side of figure 1), these artifacts and their interplay are defined. As a whole, EA is used to align IS investments with business goals. More generally, it can be used as a coordinative framework for enterprise transformation: as every change within an enterprise implies changes in different artifacts on different layers, an integral view on enterprise transformation

requires the consideration of all layers involved. (Aier et al., 2009, Winter and Fischer, 2007)

Therefore we propose EA as a blueprint for our valuation approach. The right side of figure 1 (please note only the annotations printed in bold type for the time being) summarizes the basic idea of our valuation approach: All artifacts on all architectural layers changed and enhanced by a specific IS investment have to be identified. As indicated by arrows number 1 and 2, an IS investment may lead to enhancements within the business architecture as well as within the business process architecture (“enhanced business architecture” and “enhanced business process architecture”). Then the value of these enhancements induced by the IS investment has to be determined. Following our definition in the introduction the value is measured as the delta of net cash flows resulting from affected artifacts before and after the IS investment is implemented. Based on these values we can determine the integral value of the IS investment by attributing this cash flow delta to the IS investment. This step is indicated with the arrows marked with number 3.

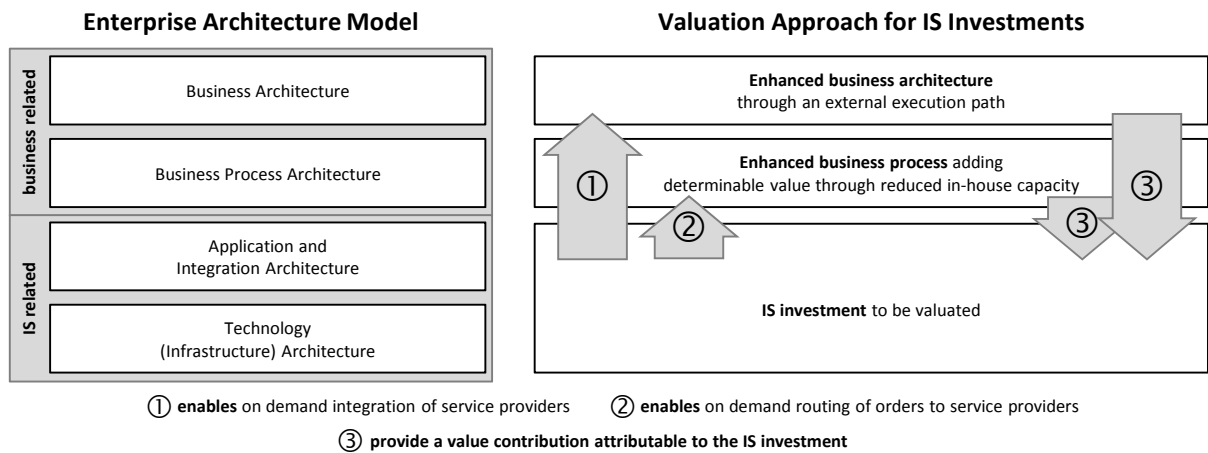


Figure 1. Valuation approach and its connection to EA (adapted EA model based on different publications, e.g. Winter and Fischer (2007) or Meschke and Baumuel (2010)).

The integral view of EA contributes with two main advantages to both challenges outlined above: First, EA can be used to identify all artifacts and their interconnections on all layers of the enterprise which are affected by the IS investment considered. Thereby, the impact of the IS investment on all architectural layers (not only the IS related) can be analyzed and considered in an integral value. Second, EA provides (detailed) models of all artifacts changed. These models can be used to support the valuation of the IS investments’ impact on the specific artifacts. Summarizing, taking into account the economic impacts of an IS investment on the different layers of a company’s EA and their artifacts, our valuation approach complements the literature referenced in the previous section and contributes to the closure of the identified research gap.

However, as the proposed valuation approach in a first step describes a rather general procedure for assessing the value of an IS investment, it has to be further tailored when applying it to a certain IS investment valuation problem. For tailoring the valuation approach, one particularly has to consider the characteristics of the IS investment regarded, the economic impacts of this IS investment on the different layers of EA as well as all artifacts affected. Depending on the peculiarities of these different aspects assumptions as well as methods for measuring the cash flow delta induced by an IS investment on the different EA layers might differ considerably. Valuating an IS investment that aims on improving the sales processes of a company and thereby leads to a potential increase in customer satisfaction requires the use of customer relationship management based methods that measure the effects on customer lifetime value. Based on such methods the cash flow delta in terms of higher returns from customer business induced by an IS investment can be assessed. In contrast, valuating IS investments that lead to improvements in the production or capacity planning processes require methods from operations research like scheduling models or queuing theory. Using such methods, the cash flow delta in terms of cost reductions e. g. resulting from more efficient production processes can

be measured. As the methods appropriate for measuring the cash flow delta strongly vary depending on the specific IS investment valuation problem, the (minimum) requirements on concepts describing the artifacts on each layer of the EA differ. Whereas e. g. measuring cost reductions in production processes requires process descriptions at a very detailed, activity based level, for other valuation purposes less granular process descriptions might be sufficient. But even if the minimum requirements differ depending on the specific valuation problem, a more detailed description of EA layer artifacts supports a more precisely measurement and attribution of cash flow effects and with that a more precisely IS investment valuation in general. Summarizing we can state, that the proposed valuation approach has to reflect and to be specified according to the respective IS investment problem as well as the characteristics of a company's EA and the artifacts on the different EA layers. Thus, our valuation approach cannot be used off the shelf, but always has to be tailored to the specific characteristics of the investment problem and the company considered.

To present how our valuation approach can be tailored to be applicable for a concrete IS investment valuation problem and with that answer our second research question, in the following we will focus on the exemplary case of IS investments enabling on demand integration. In particular, we will demonstrate how the basic idea of measuring a cash flow delta induced by an IS investment on different EA layers can be operationalized.

### **3 Tailoring the Valuation Approach: The Case of IS Investments Enabling On Demand Integration**

The value added by an IS investment of this kind is connected to the following question: How much capacity should be assigned to a business process to meet uncertain demand, when capacity cannot be adjusted in short-term? For an answer, the following trade-off has to be considered: Assigning a wrong level of capacity either results in idle costs (too much capacity assigned) or in waiting costs, e. g. caused by the violation of service level agreements (too little capacity assigned). Therefore routing excessive demand to an external service provider enabled by the IS investment can result in a considerable economic benefit as we already demonstrated in Dorsch and Häckel (2012).

Applying the valuation approach on this IS investment we can state the following (illustrated by the right side of figure 1 with all its annotations available): The IS investment enables the on demand integration of service providers changing the supplier network in the business architecture. Furthermore it enables the on demand routing of orders to these service providers resulting in reduced costs for capacity assigned to the corresponding business process. In this special case only the impact on the business process layer adds determinable value to the enterprise which can be attributed to the IS investment. Thus, following our valuation approach the cash flow delta in terms of cost reductions on the business process layer has to be measured.

To determine this cash flow delta on the business process layer, the optimization problem of capacity planning outlined above has to be modeled: The level of capacity assigned to a business process has to be determined a priori for a fixed planning horizon. Thereby, the capacity level should minimize the total operating costs. First only an in-house operating unit is available to execute the activities related to the business process. After implementing the IS investment, external service providers can be integrated "on demand" to execute the business process additionally.

#### **3.1 Modeling the business process layer without IS investment**

To measure the cash flow delta induced by the IS investment on the business process layer, an adequate method for modeling the business process as well as the trade-off within capacity planning has to be chosen. In doing so, we relate to Davenport (1993) and Hammer and Champy (1993), who define a business process as "a structured, measured set of activities designed to produce a specific output for a particular customer or market". In our case, we consider operational business processes that are in particular characterized by a random arrival rate of customer orders that trigger the

execution of the respective business process and an a priori assigned level of internal capacity that cannot be adjusted in short term. Furthermore, delays in the execution of a customer order go along with waiting costs (e. g. due to the violation of service level agreements). Concerning these characteristics of the operational business processes considered and the resulting economic trade-off in terms of capacity planning, we will regard business processes as a queuing system. This is reasoned by the fact that with help of queuing theory the waiting time of customers and thus the resulting waiting costs as well as the numbers of customers in the waiting queue can be quantified at any point of time. Therefore, queuing theory is very helpful by answering the question, how much internal capacity should be provided to minimize the total operating costs of the queuing system given a highly volatile customer demand over time. However, it should be underlined, that although modeling business processes as a queuing system is very appropriate for the case considered, it might not be suitable for other types like management processes for corporate governance or strategic decision making.

For modeling the described capacity optimization problem, we extend the basic assumptions of queuing theory by parameters and functions necessary to specify the relevant trade-offs:

(A1) *Capacity optimization problem*: An IT driven business process offers a service to our business partners. Thereby, we understand service in a management-oriented meaning as an interaction between a service provider and a service consumer that is described by the constituting characteristics of immateriality and the simultaneity of production and consumption (Chesbrough and Sporer, 2006; Rai and Sambamurthy, 2006). All activities requiring manual interventions are operated by an in-house unit. The execution of this business process is triggered following the arrival of corresponding orders. The arrival rate ( $\lambda$ ), i. e. the number of arriving orders per unit time is random. Based on historical data and contractual agreements respectively the statistical distribution of  $\lambda$  is approximated. The planning horizon considered is finite and divided into equidistant time units. We have to decide a priori about the number of orders ( $y$ ), the in-house operating unit can execute simultaneously (“capacity”), which minimizes the total operating costs ( $c$ ) for the business process:

$$\min_y c(\lambda, y)$$

(A2) *Execution time and idle capacity*: The execution time of one order is the time between the beginning of the first activity and the end of the last activity of the business process. One order uses at least one unit of capacity for this time frame. Free units of capacity are idle or can be used to accelerate the execution of orders by assigning more than one unit of capacity to an order.

(A3) *Order queuing*: The execution of an order starts with the arrival of an order unless all units of capacity within the in-house operating unit are busy. Otherwise each incoming order lines up in an infinite waiting queue. The queued orders will be executed immediately after free capacity is available according to the first in/first out principle. The time frame the order stays in this queue is called waiting time. Waiting and execution time in total are called processing time.

(A4) *Service Level*: A service level  $s$  is guaranteed to our business partners regarding the processing time. Any order which does not keep up to the service level agreed causes costs  $c_g$  per order.

Service level agreements define performance metrics as well as the compensatory payments due to broken service levels. For the optimization problem regarded a possible service level is a maximum processing time with monetary compensation for each time unit the order exceeds this limit. Another one is a fixed penalty for orders which are not executed ahead of a final deadline.

(A5) *Order execution*: The execution time  $t_i$  of the in-house operating unit for one order depends on its individual characteristics. Based on historical data the statistical distribution of  $t_i$  is stated. There are fixed costs  $c_f$  per unit capacity. The execution itself might cause additional variable costs  $c_v$  per order. The total number of internally executed orders is denoted with  $o_i$ .

These assumptions model the trade-off mentioned above: Providing too much capacity causes excessive costs of (idle) capacity. Providing too little causes excessive follow-up costs regarding the service level guaranteed. The objective function minimizing the total operating costs without

implementing the IS investment ( $c_{without}$ ) can now be stated as follows:

$$\min_y c_{without} = c_f y + c_v o_i + c_g(\lambda, y, s, t_i)$$

### 3.2 Modeling the IS investment and valuating its impact

(A6) *IS Investment*: With an IS investment (e. g. the change to a service oriented design enabling the integration of web-services automatically) external service providers can be evaluated and integrated on demand to execute all activities requiring manual interventions for an specific order instead of the in-house operating unit.

(A7) *Service market*: All activities the in-house operating unit executes on arriving orders are offered by the market as standardized services. The necessary technologies (e. g. service repositories and well described services based on standardized description languages) for a quick and mostly automated on demand evaluation and integration of service providers are established.

The IS investment along with the corresponding service market supplements the in-house operating unit (internal execution path) by an external execution path. Furthermore, due to the flexibility of on demand evaluation and integration of external service providers each incoming order can be routed to the execution path which offers “best execution” at the relevant time.

(A8) *Order routing decision*: For each incoming order the execution path has to be selected. An order is routed to the in-house operating unit or to the external execution path. The routing decision is made based on the expected processing costs which have to be evaluated for each external service provider. The execution path with lower processing costs is chosen.

Depending on the cost-based optimization problem outlined in (A1) “best execution” is determined by processing costs. These costs subsume all characteristics of an execution path which have to be taken into account for a specific setting, e. g. processing time, fixed and variable costs, quantity discounts or minimum purchasing quantity. The processing costs for the in-house operating unit are stated above. For the external service providers the following characteristics have to be considered:

(A9) *Evaluation and integration of external service providers*: A set of external service providers which are basically qualified to execute the activities requiring manual interventions is identified in advance. All relevant information to evaluate this set of external service providers with regard to current processing costs is provided constantly by the market.

The external execution path is used in addition to the in-house operating unit. It is established to execute peaks otherwise would have to be balanced with additional capacities for the in-house operating unit. Therefore we do not book capacities on the external service providers market in advance as therefore usually fixed costs arise analogous to additional capacity for the in-house operating unit. In fact we are going to route orders on demand to external service providers market:

(A10) *Availability of external service providers*: Regarding their availability to execute orders no service level is agreed with the set of external service providers. Orders can be executed externally only if capacities of one or more external service providers are (temporarily) underutilized. Therefore the time frame  $a$  until external capacity is available is exogenous but can be determined using the information constantly provided by the market (see A9).

This leads to an analogue setting as for the in-house operating unit: With  $a > 0$  externally routed orders cannot be executed immediately and have to queue up until free capacity is available. As the waiting time in the queue in front of the external service provider’s market ( $a$ ) is exogenous and therefore cannot be calculated, the necessary data has to be provided as one of the necessary information mentioned in (A8). This exogenous waiting time furthermore carries risks as it might be too long to support the in-house operating unit in executing orders within the service level agreed. These risks have to be considered within the processing costs for the external execution path to make an appropriate order routing decision.



(A11) *Order execution within the external execution path*: The execution time  $t_e$  on the external service provider's market for one order depends on its individual characteristics. Based on historical data the statistical distribution of  $t_i$  is stated. There are no fixed costs but variable costs  $c_e$  which come up with the external execution of an order. These include not only the price for order execution to be paid to an external service provider but also the costs related with the evaluation and integration of the service provider. As prices may differ between different external service providers or even within one external service provider depending on its utilization, the respective price has to be provided along with the information about availability mentioned in (A9). The total number of externally routed orders is denoted with  $o_e$ .

Assumptions (A6) to (A11) model the additional trade-off between the waiting cost resulting from the queue in front of the in-house operating unit and the time until an appropriate service provider can be identified and integrated. The objective function minimizing the total operating costs with the IS investment ( $c_{with}$ ) can be stated as follows:

$$\min_y c_{with} = c_f y + c_v o_i + c_e o_e + c_g(\lambda, y, o_i, o_e, s, t_i, t_e, a)$$

Knowing the cost-functions connected to the business process, the cash flow delta within the respective minimum can be calculated with

$$\Delta CF = \min_y c_{without} - \min_y c_{with}$$

Adjusting the planning horizon considered for the optimization problem to the planning horizon of the IS investment, the value then can be attributed to the IS investment.

### 3.3 Characteristics of the case study

The following case study is based on data available from a large provider for banking transaction services ("banking factory") who has to decide about an IS investment enabling the on demand integration of external service providers supporting the payment transaction process. This process includes all activities to execute payment orders like bank transfers, direct debits, checks, drafts and returns as well as debit and credit card payments. The impact of the IS investment is linked to one of the rare manual activities within this process: After all forms and media is scanned and the data is extracted to the processing IT system, the orders are checked automatically and all orders which need manual rework (e. g. correction of incorrect scans or completion of missing details) are selected. This rework is done within an in-house operating unit before all subsequent activities take place.

Staffing the in-house operating unit is an important optimization problem for the banking factory. As a cost-driven support process the margins for processing payment orders are small. Therefore the capacity of the in-house operating unit should be kept as small as possible to reduce the corresponding costs to a minimum. However, there is only limited time for executing the payment orders as the clients of the banking factory agreed detailed service levels concerning the time frame for execution, e.g. to meet regulatory standards. Along with the large amount<sup>1</sup> and the volatile arrival rates of incoming orders there is a trade-off between idle times or delayed execution respectively. This is where the IS investment can help: With implementation of this IS investment it is possible to route orders for manual rework to external service providers. This can be done on demand whenever this path is expected to cause lower processing costs than the rework in the in-house operating unit.

The (simplified) characteristics of the payment transaction process necessary to apply our model are identified as follows: Orders are accepted every bank working day between 7 a.m. and 10:00 p.m. Analyzing historical data reveals different peaks concerning the arrival rate of the incoming orders

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<sup>1</sup> One of Germany's market leaders in payment transaction processing with a market share of about 20 % processes an average of 30 million transactions a day. The corresponding volume of money transferred is about EUR 120 billion.

depending on exogenous factors like billing cycles of the central bank or closing times. Dividing the 15 hours of order acceptance in seven time-frames, the arrival rate within each time-frame can be approximated by an exponential distribution with different means as summarized in table 1.

7:00 a.m. – 8:30 a.m.	8:30 a.m. – 2:00 p.m.	2:00 p.m. – 3:00 p.m.	3:00 p.m. – 6:30 p.m.	6:30 p.m. – 8:00 p.m.	8:00 p.m. – 9:30 p.m.	9:30 p.m. – 10:00 p.m.
120,000	6,000	60,000	40,000	8,000	100,000	6,000

*Table 1. Arrival rates within a bank working day (mean number of orders per minute following an exponential distribution)*

About 0.05% of the incoming orders need manual rework. The rework of an order takes 4:00 minutes in average not dependent of the execution path. Idle capacity cannot be used to accelerate the execution of orders as within this single activity only one employee can work on one order. Cost accounting reveals that one unit of capacity within the in-house operating unit causes fixed costs amounting to EUR 240 a bank working day. There are no additional variable costs.

The service level agreement between the financial service provider and the banking factory consists of two deadlines: First, each order has to be processed within 60 minutes after arrival. For each minute an order exceeds this time frame, a compensation amounting to EUR 0,033 per minute is due. As this time frame applies to the whole business process, it has to be apportioned to the single activity of manual rework considered within the optimization problem. This reveals a maximum of 12 minutes for this single activity to ensure an order is processed within 60 minutes after arrival. Second, there is a final processing deadline each day: All incoming orders have to be processed until 12:00 a.m. For each order not processed within this deadline the compensation payment rises to a penalty of EUR 51.

The planning horizon for the IS investment is determined with five years (with 250 bank working days each). A set of external service providers qualified for manual rework is identified and a fixed price for an order was agreed. Hence the variable costs for one order sum up to EUR 1.96. Based on historical data provided from these external service providers the waiting time in the queue in front of the external service provider's market can be approximated. During a bank working day three time frames with different utilization of the market's capacities are identified. Each time frame shows different waiting times for free capacity which can be approximated by a normal distribution as outlined in table 2. Orders which have to be executed externally have to wait according to the time frame valid at the time the order is routed to the external service provider's market.

7:00 a.m. – 12:00 noon	12:00 noon – 6:00 p.m.	after 6:00 p.m.
$\mu = 16:40; \sigma = 4:00$	$\mu = 12:00; \sigma = 2:10$	$\mu = 10:00; \sigma = 4:00$

*Table 2. Distribution parameters of the waiting time in queue in front of the external service provider's market (mean  $\mu$  and standard deviation  $\sigma$  in minutes)*

### 3.4 Setting up the discrete event simulation

As there is no mathematical model available considering all necessary characteristics of our model, we have to perform a discrete event simulation to solve the optimization problem. To determine the cash flow delta induced by the IS investment, the simulation has to be performed with and without the external execution path. For both cases we proceed as follows: To determine the optimal in-house capacity we perform multiple simulation experiments with increasing values for the capacity of the in-house operating unit. Each experiment consists of 1,000 simulation runs. For each run the total operating costs are determined. Starting the experiments with one unit of in-house capacity, we increase the value by one unit before the next experiment is started. This is done until the results of an experiment show that no waiting costs occur in front of the in-house operating unit for all runs. From this it follows a further increase of capacity does not have any positive effect concerning the total operating costs. Finally, comparing the average total operating costs for each experiment and choosing

the one with the lowest costs then leads to the optimal in-house capacity.

With regard to the simulation time it is convenient that all bank working days of our case study are independently of each other (e. g. no unexecuted orders left due to the processing deadline at 12:00 a.m.) and the relevant events which determine the optimal in-house capacity are recurrent each bank working day. Therefore we do not have to simulate the whole planning horizon of the IS investment. In fact it is sufficient to determine the optimal in-house capacity along with the corresponding value of the IS investment for a single day. The results then can be projected.

For each simulation run incoming orders are generated randomly following their statistical distributions. Whenever a new time frame is reached, the arrival rate is adapted. Concerning the external service provider's availability a random value is generated from the corresponding statistical distribution at the beginning of each time frame outlined in table 2. This value applies as the approximated waiting time for free capacity for the whole time-frame. Repeating a simulation run 1,000 times the risks connected to the waiting times for free capacity at the external service provider's market are considered when using the simulation results to determine the optimal capacity.

Furthermore a routing algorithm is developed. It determines the processing costs for each incoming order and chooses the execution path with lower processing costs: The processing costs of the internal execution path result from the service level agreement with the financial service provider only. There are no variable costs and all fixed costs are sunk costs which must not be taken into account. From the service level agreement costs can occur in two different ways as described above. For the external execution path the processing costs consist of the variable cost per order and the costs resulting from the service level agreement determined analogous.

### 3.5 Valuating the IS investment

The simulation reveals the influence of the cost associated with the service level agreement on the total operating costs: Very small in-house capacity results in a high amount of unexecuted orders and the total operating costs are very high due to the corresponding penalties. With increasing capacity, more orders are executed during a bank working day ahead of the final processing deadline and the total operating costs decrease accordingly. These costs along with the fixed costs of capacity shape the total operating costs to a convex graph with a global minimum.

The advantage gained with the IS investment can be determined by comparing the graphs of the total operating costs as outlined in figure 2 on the next page. The optimal in-house capacity as well as the corresponding total operating costs can be reduced when the external execution path is available. Identifying the capacity level with lowest total operating costs leads to the optimum.

The value of the IS investment for one bank working day then is determined by calculating the cash flow delta ( $\Delta CF$ ) induced by the IS investment:

$$\Delta CF = 43,747.96 \text{ EUR} - 41,011.92 \text{ EUR} = 2,736.04 \text{ EUR}$$

For the planning horizon of the IS investment (five years with 250 working days each), the attributable value adds up to EUR 3,420,050 million equivalent to 6.3 % of the total operating costs.

## 4 Summary and Future Work

IS investments transform the enterprise as a whole by changing both, the IS and the business related architecture. To make conscious decisions with regard to these investments, the value added on all architectural layers of an enterprise has to be considered in an integral view.

As through EA all artifacts of an enterprise and their relationships which are affected by IS investments are known, the proposed approach offers two main advantages: First, the impact of IS investments on all architectural layers can be identified and attributed to the IS investments within an integral value. Second, EA provides (detailed) models of all artifacts changed. These models can be

used to support the valuation of the IS investments' impact on the specific artifacts.

The case presented was used to demonstrate the general applicability of the valuation approach. Of course, IS investments transforming the enterprise to the extent that on demand integration is possible, not only affect a single business process. Rather all affected business processes and their interrelation have to be considered as well as the interrelation between artifacts on different layers affected by the IS investment. Thereby a higher or lower value of the IS investment may result.

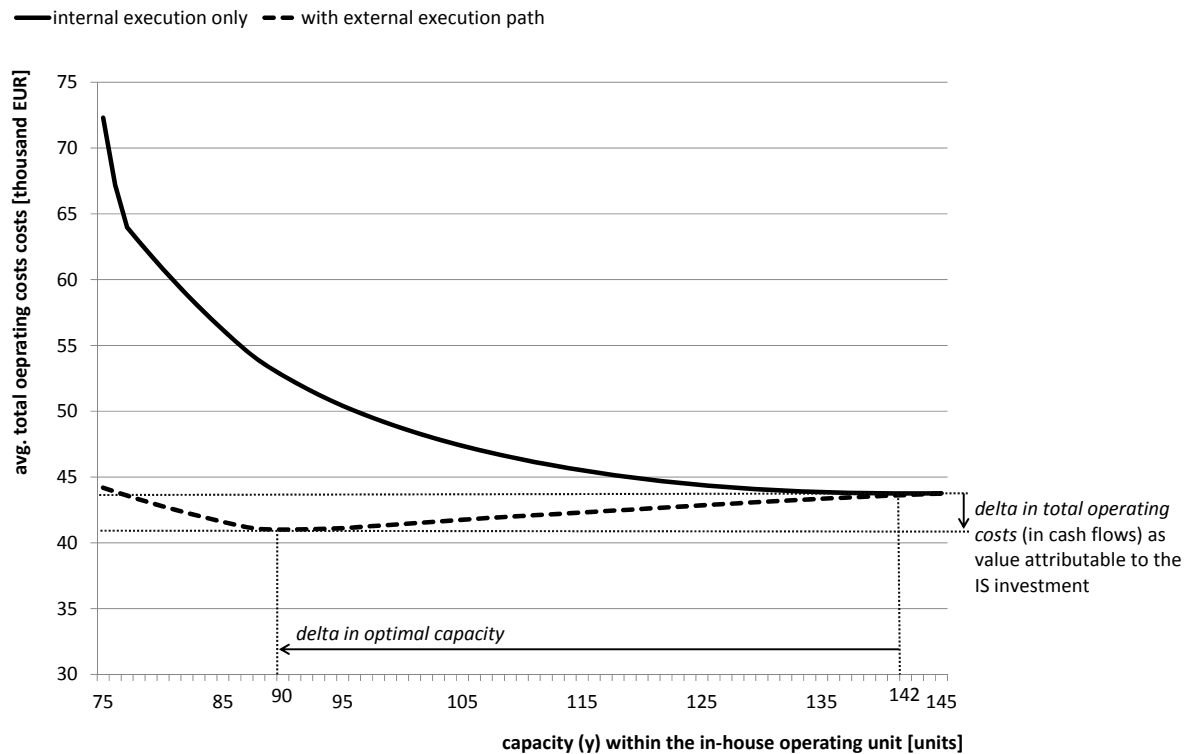


Figure 2. Total operating costs and its minima with and without the IS investment

Further work is necessary to elaborate the proposed valuation approach to a *valuation framework* serving as a guideline for practitioners. Within this paper, the proposed valuation approach in general remained highly abstracted being detailed with one case specific valuation model and a corresponding case study. In accordance to artifacts specified within the different domains of EA the aimed valuation framework i.e. should be detailed with general valuation models addressing (domain) specific artifacts and their change through generalized but corresponding IS investments. Similar to EA, providing blueprints for modeling and other well-known purposes, this detailed valuation framework then provides blueprints supporting the valuation of enterprise transformation from an integral view.

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