Development of an extended selection algorithm for projects in a project portfolio

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ABSTRACT

This paper touches the current state of the art for selection algorithms of projects in a project portfolio and extends the existing approaches by prioritizing projects according to their strategic contribution based on a Balanced Scorecard (BSC).

Keywords

Balanced Scorecards(BSCs), project portfolios, selection algorithm

1. INTRODUCTION

Project Portfolio Management (PPM) is a field of research that becomes more and more important – mostly driven by economic thinking, competition and regulations. Especially regulations like the Sarbanes-Oxley Act (SOX) require companies to document decisions and the according decision making process. PPM represents a framework for doing this in the environment of projects and project portfolios. The paper gives a short overview on the fundamentals of PPM and focuses on the selection process for projects to become part of a portfolio. The other parts of the PPM-process are not touched in this paper – reference for continuative literature is made at the respective sections in the paper.

The algorithm developed in chapter 3 can be applied to any kind of project in any industry, as the criteria are based on Project Management Standards and on company-specific criteria coming from the implementation of a Balanced Scorecard (BSC). If the company has already a BSC in place, the algorithm can be directly implemented.

After the development of the algorithm, the paper shows the application with some test-data taken from a bank. This part focuses on optimizing a sample portfolio with test data and given constraints.

The methodology itself cannot guarantee the success of the projects in a portfolio, as this depends on various other factors as well, but it ensures the traceability of the selection of the projects in this portfolio.

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2. STATE OF THE ART IN PROJECT PORTFOLIO MANAGEMENT (PPM)

The role of Chief Economic Officers (CEOs) in the past was mainly driven by optimizing economies of scale for the companies they were leading. Research and development was a minor success factor as the life-cycles of products lasted over years and the competition was driven by the price rather than by unique selling points for specific products. Over the time markets evolved and products moved closer and closer to the special requirements of various customer groups – the diversification increased.

The companies needed to adapt their organizatorical structures and processes in a way to be more efficient and to react quicker to the needs of the market. In parallel legal restrictions like the Sarbanes-Oxley Act (SOX) and the right of the stakeholders to understand and follow up on the decisions made by the board forced them to increase their level of Corporate Governance. Criteria like Profitability, Return on Investment (ROI) and Windows of Opportunity were extended by topics to optimize the implementation of the company's strategy:

- What mix of potential projects will provide the best utilization of human and cash resources to maximize long-range growth and return on investment for the company?
- How do projects support strategic initiatives?
- How will the projects affect the value of corporate shares (stock)?

To answer these questions, the projects within the company needed to be managed following the mission and implementing the strategy of the company. This is what led to the current best-practice in the implementation of PPM.

2.1 Historical development of PPM

In 1952 Harry Markowitz described the Modern Portfolio Theory (MPT) for the first time in his seminar paper "Portfolio Selection" in the Journal of Finance [MAR52].

In 1981 F. Warren McFarlan applied MPT to the management of projects. In the Harvard Business Review entitled "Portfolio Approach to Information Systems" [MCF81] he recommended employing a risk-based approach to select and manage projects.

In 1994 the US Government Accountability Office's (GAO) report "Improving Mission Performance Through Strategic Information Management" [GAO94] described the private

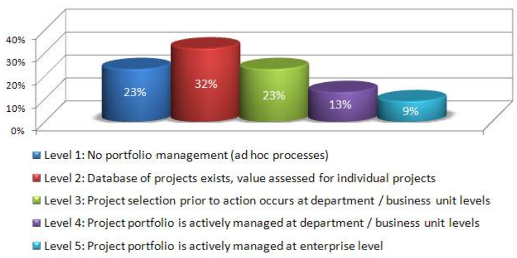


Figure 1: Distribution of organizations regarding the implementation of PPM

Figure 2: PPM seen as a bridge

sector organizations using a portfolio investment process to select, control and evaluate projects.

In 1998 the GOA published the "Executive Guide: Measuring Performance and Demonstrating Results of IT investments" [GAO98]. Portfolio management and analysis were pointed out as one of four strategic enterprise objectives.

Since the introduction of SOX in 2002, companies noted at the stock exchange have a special demand to be transparent in the use of their capital and the actions they pursue. Project Portfolio Management proved to be one possibility to comply with the regulatory standards by effectively managing the companies' resources. Figure 1 describes the level of implementation as of 2005 [PS05].

2.2 Definition of PPM

As projects became more and more important over the years, traditional organizations organized around operations where extended with a second field for project execution. They were controlled separately from each other and many of the stakeholders recognizing the shortcomings of this approach considered PPM to be the bridge between the two worlds like shown in figure 2. The reasoning behind this is based on the fact that operations and projects utilize the same resources but have different views on them. The functional departments focus on business performance, project manager focus on their projects' performance; the satisfaction of the stockholders is of interest for the business whereas projects are more interested in the satisfaction of the stakeholders – just to give two examples. In fact PPM is much more than that; following the definition of [CEK99] and [CEK01] PPM needs

- to maximize return and achieve financial goals
- to maintain the competitive position of the business – to increase sales and market share
- to properly and efficiently allocate scare resources
- to forge the link between projects selection and business strategy

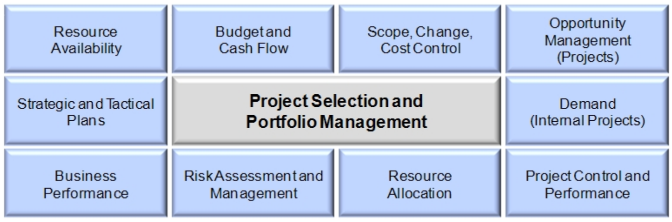


Figure 3: PPM seen as a hub

- the portfolio is the expression of strategy – it must support the strategy
- to achieve focus – not doing too many projects for the limited resources available and providing resources for the great projects
- to achieve balance – the right balance between long- and short-term projects and high-risk and low-risk ones, consistent with the business's goals
- to better communicate priorities within the organization vertically and horizontally
- to provide better objectivity in project selection and weed out bad projects

This alters the original picture towards a new understanding of PPM: PPM acting as a hub servicing various interests and functions (figure 3).

- Strategic and tactical plans
  the proper prioritization of projects according to their relevance to the strategy and the progress of execution to achieve the targets set need to be monitored.
- Resource Availability
  resources for upcoming projects need to be scheduled and planned carefully as there is normally some lead time for all of them: e.g. human resources need either to be trained or hired, financial resources like loans need to be applied for.
- Budget and Cash Flow
  budgets for projects need to be cross-checked and the cash flows determined to plan the needed financial resources.
- Scope, Change and Cost Control
  the scope of any of the projects in the portfolio needs to be monitored tightly as all the dependencies to other projects in the portfolio depend on it. Changes might affect not only a project but the whole portfolio.
- Opportunity Management
  if there are opportunities for optimizing the portfolio, they need to be recognized and managed. This function has a wide field of activity starting from the recognition of newly raised dependencies between projects in the portfolio over changes in the market to better allocate resources to moves of competitors that might change the implementation plans for the company's strategy.

- Demand (Internal Projects)
  besides the strategic projects of a company there is also the need for projects that might not have direct impact on it but are required to improve certain processes.

- Project Control and Performance
  the ongoing projects need to be monitored in terms of classical project management procedures to understand the progress and realize the impact of the evolvement on other projects in the portfolio.

- Resource Allocation
  the resources need to be distributed over the projects to optimize the possible output. As the resources are limited this needs to be handled in with a portfolio optimization approach like the Modern Portfolio Theory (MPT) from H. Markowitz.

- Risk Assessment and Management
  the risks for the projects and the whole portfolio need to be accessed during the selection of the projects and during the whole life-time as risks evolve over time. The responsibility of PPM is to protect the company from unexpected risk.

- Business Performance
  the execution of the projects and the portfolio is very important but the crucial point for the company's success is, if the projects delivered return the business value expected. Therefore the implemented projects need to be reviewed after their closure for the return of the investment and the conclusions for ongoing and future projects need to be drawn.

2.3 The Process Model of PPM

In contradiction to the execution of projects PPM does not have a defined beginning nor has a defined end as it is an ongoing process. However the process can be divided into five phases which are often separated with methods like the Stage Gate® Process, meaning that they are only allowed to enter the next phase if the phase before is finished and certain criteria are fulfilled. The phases for PPM are defined as follows:

- Identification of needs, goals and objectives
  in the first step the requirements for the portfolio are defined. The needs describe the reasons why the company implements PPM. The goals and objectives define the targets to achieve and the measures to quantify them. Taking these as a baseline the selection criteria are built or updated to choose the proper projects for the portfolio. As expectations towards PPM evolve over time and the acceptance and success of PPM depends on clear expectation management, this step is not defined as a one-time preparation step but is an integral part of the PPM-life cycle. Important to mention is that the objectives should stay as stable as possible over the time – a change in the objectives for the PPM means that the traceability of the portfolio is disturbed.

- Selection of the best combinations of projects (the portfolios)
  the quality of the portfolio depends to a large extend on the quality of the selection-criteria defined in the first step. In addition the current business strategy and actual targets are taken into consideration to pursue the right set of projects. Details will be discussed in the chapter dealing with criteria for selecting projects.

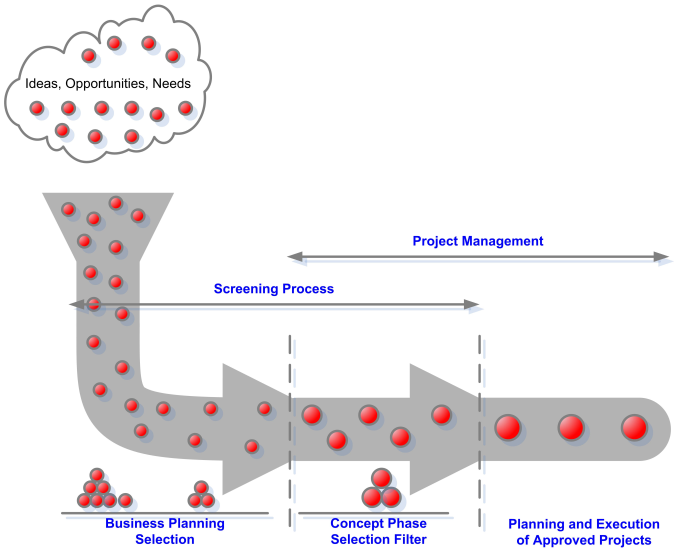


Figure 4: The first three steps of the Project Portfolio Life Span

- Planning and execution of the projects
  this step deals with the scheduling and the conduction of projects in the portfolio. It must not be mixed up with the planning and execution of projects in terms of project management as the focus on this phase is on the state of the portfolio and the contribution of each single project to the portfolio and not on the details of the projects in the portfolio.

- Monitoring portfolio performance
  the monitoring focuses on the delivery of the expected project deliverables and their contribution to the development of the portfolio. Variations of the plans are detected and corrective actions or change requests are set. The main deliverable of this phase for the board of the company is a dashboard providing them with the information what the actual status on the implementation of the strategy is.

- Realization of benefits
  the last phase in the cycle is used to compare the implementation of the project deliverables and their business impact to the expected results. This step does not only provide information on the achievements of goals but needs to be used to question the reasons in case of failure as well. They might give new or additional input to the first cycle again and help defining the needs, goals and objectives.

There is no general recommendation on the duration per iteration of the life cycle as a reasonable time frame depends on the projects in the portfolio. However, for most of the portfolios a benchmark should be a month.

The portfolio life-cycle described up to now leaves open, how the Project Management methodology is embedded.

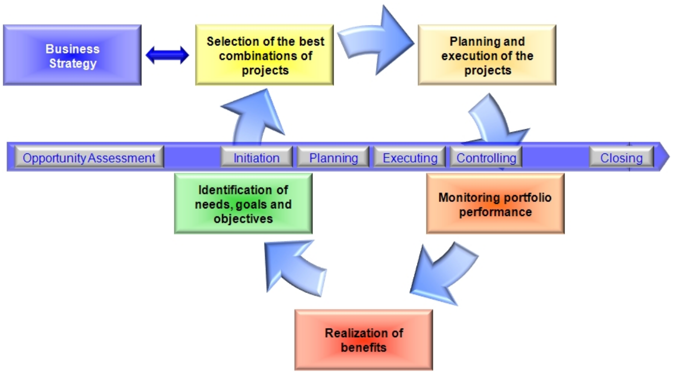


Figure 5: Life cycle of PPM in combination with Project Management

The best-practice solution which is proven by various implementations is shown in figure 5.

As projects have different start-dates, milestones and end-dates, they cannot be synchronized in a way that they fit in a phased approach were all of them sharing the same rhythm. Therefore PPM needs to adapt and be so flexible to handle projects in various stages of their life-cycle and still fulfil its function. The approach in figure 5 shows that ideas and opportunities are collected in the very beginning but are treated outside the PPM-Cycle itself (but in the PPM-responsibility as displayed in figure 3). After an opportunity or idea has been selected, the initiation phase for the project starts from where it continues through the whole project management life cycle (Initiation – Planning – Executing – Controlling) besides Closing. During all the time PPM oversees the project and monitors it. As soon as it comes to Closing, the project quits the life cycle, as this part is administrative only and does not impact the value delivered to the portfolio any more.

As this paper focuses on extending the existing selection algorithms, it will only deal with optimizing the value of the portfolio by using the proper set of criteria to prioritize projects. For the other process steps reference is made to the explanations in [LEV05], [PS05], [COO05], [PMI06] and [RMW07].

3. A NEW APPROACH FOR SELECTING PROJECTS IN A PROJECT PORTFOLIO

The existing approach introduced in chapter 2.3 contains weaknesses in terms that some major aspects of an efficient PPM are not fulfilled:

1. The existing project portfolio optimization models are based on the methodology of Markowitz [MAR52] but do not consider one important fact: Markowitz based his theory on financial portfolios. The difference between financial and project portfolios in this relation is, that financial ones are continuously distributed whereas project ones are discretely distributed. This is because in financial portfolios shares or derivatives can be sold or bought in arbitrary pieces whereas projects can be executed or not – the execution of 50% of a project by gaining 50% of the benefit is unrealistic. In projects the earned value cummulates over all deliverables of the project and the benefit cannot be split or partially fulfilled by a certain number of deliverables. Explanations on the difference between continuous and discrete distribution can be found in [KRE98].

2. Further the projects are evaluated by themselves but not by their value contribution they have with their dependencies to other projects. This means that projects with a low value by themselves but acting as an enabler for high-valued projects might not be implemented. A special case in this coherence are projects in a portfolio that do not provide a business need itself but are obligatory (e.g. needed to fulfil regulations set by the government).

3. The quantifying measures to prioritize the projects are related to financial figures only. They do not take the influences on other key performance indices (KPIs) relevant for the company into consideration. Therefore this approaching is lacking to optimally support the strategy of the company.

4. The assumption for most existing optimization algorithms is, that the limitation of human resources can be resolved by investing additional money to buy additional "Know-How". In reality, this is normally not true as sensitive and important projects require special people with high sophisticated skills.

The approach that should be developed in this chapter tries to address all these issues and will provide suggestions to resolve them in a way that project portfolios can be optimized fully considering them.

3.1 The distribution of a project portfolio

The first weakness identified goes along with the distribution of a project portfolio. [GRU05] explains that

> "The Efficient Frontier curve shows all of the best possible combinations of project portfolios and the value that can be created with available capital resources in an unconstrained mode."

and further

> "The Efficient Frontier shows the opportunity cost of investing an additional dollar versus the additional value received."

The second statement implies that an arbitrarily chosen amount of money adds additional value to the project defined by a certain function. This would also mean that projects can be split in smaller pieces by delivering a smaller value that can be determined.

In reality this does not work out. Imagine a car manufacturer that needs to develop two new cars: the first one takes development cost of 500 million dollar and the second one of 600 million dollar, the budget of the company is 800 million dollar. Following the Efficient Frontier approach would mean that the company could e.g. run the project for the first car and invest the remaining money into the project for the second car. Obviously there is a value for project one if we assume that it is finished successfully and it goes into production and into sales – the money invested into the second project does not provide any value so far: a car where the product development is not finished can neither be produced nor sold.

The issue can only be solved by changing the approach from arbitrarily changes in size to changes in terms of full projects – this implies further that the type of distribution that needs to be used is not a continuous one like [MAR52] used for financial portfolios but a discrete one: a distribution that shows all possible portfolio combinations. For simplification purposes at the beginning the following topics are not considered – they will be added later on:

- dependencies to other projects
- observations beyond the point in time t_0
- obligatory flags for projects
- limiting constraints

This determines the number of portfolios alternatives to be a combination of n different projects taken k at a time, without repetitions or

$$\binom{n}{k} = \frac{n!}{k!\,(n-k)!} \tag{1}$$

This needs to be repeated for possibilities of k (the number of projects that can be executed in parallel). In theory k can be any number between 1 and n because without dependencies and limitations all projects could be executed; limiting k only makes sense if the stakeholders do not want to support more than a maximum of k projects at the same time:

$$\sum_{k=1}^{n} \frac{n!}{k!\,(n-k)!} \tag{2}$$

The first complexity to be added are the dependencies. Formally it means that for a portfolio at t_0 only projects that to not rely on any other project can be executed. All other projects need to wait for the finishing of their predecessors; this reduces the complexity of the project portfolio by

$$\sum_{k=1}^{n} \frac{n!}{k!\,(n-k)!} - \sum_{k=1}^{m} \frac{m!}{k!\,(m-k)!}$$

or

$$\sum_{k=1}^{n-m} \frac{(n-m)!}{k!\,(n-m-k)!} \tag{3}$$

where m are the number of dependent projects in the portfolio. This finding needs to be handled with high caution as it might lead to a failure: prioritizing now the portfolio based on the value of the projects in t_0 would lack the vision that is necessary in PPM: a future oriented approach should keep in mind all combinations of projects including the value of each path – a sample path diagram based on dependencies in a project portfolio is shown in figure 6.

Thus the algorithm needs to be extended to not only look at t_0 but considering the whole timeline until the finalization of the last project to optimize the portfolio on the maximum expected benefit out of all options in the future. Therefore every project needs to be listed with all its dependencies:

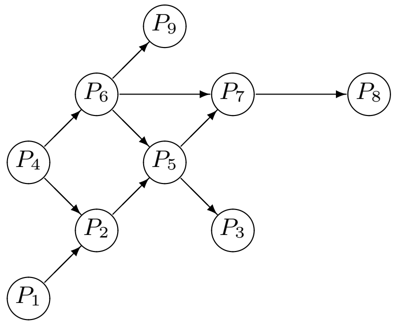


Figure 6: Sample dependency tree for a project portfolio

Project	Dependencies
P_1	-
P_2	P_1, P_4
P_3	P_1, P_2, P_4, P_5, P_6
P_4	-
P_5	P_1, P_2, P_4, P_6
P_6	P_4
P_7	P_1, P_2, P_4, P_5, P_6
P_8	P_1, P_2, P_4, P_5, P_6, P_7
P_9	P_4, P_6

3.2 The value of project options in a project portfolio

As the various paths in the project portfolio are known based on their dependencies, the next step is to benchmark every option for its value. Naturally the prioritization would take place by sorting them by a certain selection criteria. The issue using this approach is, that the duration of the project(s) is not considered and therefore the return on the various options is not evaluated on the same baseline. For this reason the indicator needs to be discounted over the duration of the project respectively the duration of projects within the option:

$$\text{Option Value} = \sum_{p} \frac{\text{Indicator}}{(1+r)^{d_p}} \tag{4}$$

where p represents all projects in the option, r is the discount rate per period and d_p is the period from the beginning of the portfolio's perspective to the end of the considered project (not the portfolio!). Caution needs to be taken in case the indicator chosen is already discounted like the NPV or a derived one. An effective indicator for the Option Value will be introduced in section 3.4.

There might be situations where projects in a portfolio are obligatory e.g. for regulatory reasons. These projects might not return any direct value to the company. Therefore they need to be incorporated separately as they would otherwise never make it into the project portfolio. The solution is to mark them and all the projects they depend on directly and indirectly as mandatory, considering them before the priority list given by the indicator.

By now the approach addresses the issues one and two identified at the beginning of the chapter – the next step must be to find a solution to problem number three: the solution described so far relies on financial KPIs only, but does not consider further influences of the project on the company.

3.3 Quantifying measures beyond financial KPIs

This section deals with the fact, that indicators cannot only be taken from the financial information that goes along with the execution or finalization of the project but also with the influence on and from other components of the success of a company. This paper distinguishes between two types of such indicators: the ones derived from a Balanced Scorecard and others taken from standard project management methodology defined by the Project Management Institute (PMI) respectively well known indicators out of standard project management.

3.3.1 Measures from a Balanced Scorecard

The first possibility to extend the traditional view is to follow a Balanced Scorecard (BSC) [KN96] approach by taking the measures and KPIs identified in a BSC to determine the influence of a project on this BSC. This implies that the projects can be evaluated on their contribution to the strategy that is defined in the BSC.

The BSC identifies objectives and the influences between these and tries to bring them down to factors that do not represent aggregates figures but are pure values that cannot be further decomposed (so called α-figures). Their transformation to the operational KPIs is defined in the mathematical model of the BSC which provides the first of the transformations needed to get the target values for prioritization in this model. The figure below describes the projects in a portfolio ($P_1 \ldots P_m$), the BSC input variables ($\mathrm{B}\alpha_1 \ldots \mathrm{B}\alpha_n$) and the BSC output variables ($\mathrm{B}\beta_1 \ldots \mathrm{B}\beta_n$). The B stands for BSC – there will be additional input- and output-variables described afterwards, so this identifier is needed.

Project	BSC Input Variables		
	$\mathrm{B}\alpha_1$	$\ldots$	$\mathrm{B}\alpha_n$
P_1	$P_1\mathrm{B}\alpha_1$	$\ldots$	$P_1\mathrm{B}\alpha_n$
$\vdots$	$\vdots$	$\ddots$	$\vdots$
P_m	$P_m\mathrm{B}\alpha_1$	$\ldots$	$P_m\mathrm{B}\alpha_n$

$\Longrightarrow$

Project	BSC Output Variables		
	$\mathrm{B}\beta_1$	$\ldots$	$\mathrm{B}\beta_o$
P_1	$P_1\mathrm{B}\beta_1$	$\ldots$	$P_1\mathrm{B}\beta_o$
$\vdots$	$\vdots$	$\ddots$	$\vdots$
P_m	$P_m\mathrm{B}\beta_1$	$\ldots$	$P_m\mathrm{B}\beta_o$

For the evaluation of projects it is important to understand how the finished project will change the α-figures of the BSC. Out of the transformation (a n:m transformation between input- and output-variables) the expected change in the strategic figures can be calculated (the β figures).

3.3.2 Measures taken from Project Management

So far this section dealt only with KPIs determining the alignment of a project with the strategy of the company. In addition there are other KPIs that deal with project inherent data and are necessary for the selection process as well. The ones the paper is referring to are the ones of the Project Management Institute (PMI) defined in the Project Management Body of Knowledge (PMBOK®) [PMI04].

The input parameters (or α-figures) can be defined as follows:

- Planned Project Duration
- Skills
  gives a description for every skill the projects requires to be executed.
- Demand of the skill
  quantifies the amount of hours/days/weeks/months a skill is needed within a defined period. It is important to understand that the demand summarizes the whole demand of a specific skill in a requested period. This means if a project requires e.g. five persons full-time for a month then the demand is five man-months within a month.
- Rate of the skill
  describes the rate to be paid for the specific skill. The scale chosen needs to be the same as the scale the demand is given in and needs to be available or estimated for all periods the project is planned to be executed in.
- Investments
  depict the investments planned within the project.
- Investment cost
  determine the cost that go together with the investments described.
- Risks
  the risks that go along with the project need to be identified.
- Lowest possible impact for every risk identified
- Probable impact for every risk identified
- Highest possible impact for every risk identified
- Direct dependencies to other projects
  the dependencies included may only be mandatory dependencies for the execution of the project. Sometimes they become mixed up with so called discretionary dependencies sourcing from e.g. resource shortages – they need to be filtered and removed as the selection algorithm would not work efficiently in this case. Section 3.5 shows that this kind of dependencies comes from constraints within a portfolio.

Out of these factors the following output-parameters (or β-figures) can be derived. Formally they underlie the same kind of transformation that can be seen with the factors from the BSC – projects in a portfolio ($P_1 \ldots P_m$), the project input variables ($\mathrm{P}\alpha_1 \ldots \mathrm{P}\alpha_n$) and the project output variables ($\mathrm{P}\beta_1 \ldots \mathrm{P}\beta_n$).

Project	Project Input Variables		
	$\mathrm{P}\alpha_1$	$\ldots$	$\mathrm{P}\alpha_p$
P_1	$P_1\mathrm{P}\alpha_1$	$\ldots$	$P_1\mathrm{P}\alpha_p$
$\vdots$	$\vdots$	$\ddots$	$\vdots$
P_m	$P_m\mathrm{P}\alpha_1$	$\ldots$	$P_m\mathrm{P}\alpha_p$

$\Longrightarrow$

Project	Project Output Variables		
	$\mathrm{P}\beta_1$	$\ldots$	$\mathrm{P}\beta_q$
P_1	$P_1\mathrm{P}\beta_1$	$\ldots$	$P_1\mathrm{P}\beta_q$
$\vdots$	$\vdots$	$\ddots$	$\vdots$
P_m	$P_m\mathrm{P}\beta_1$	$\ldots$	$P_m\mathrm{P}\beta_q$

Total Labour Cost (TLB).

The cost of labour depends on the demand for specific skills and their rate. This formula is only to calculate the cost of labour – at this point in time it is not yet considered that the availability might be an issue; it will be discussed later on during the further development of the algorithm.

$$\text{TLB} = \sum_p \sum_s rate_{ps} \times demand_{ps} \quad (5)$$

where p represent the periods of the project and s the skills needed.

Total Investment Cost(TIB).

The investments planned within the project – also important to calculate depreciation for the spendings on inventory goods out of a project, which can also be used as an indicator in the prioritization of the portfolio (e.g. percentage of the project budget that can be activated for depreciation):

$$\text{TIB} = \sum_p \sum_i investment_{pi} \quad (6)$$

where p represent the periods of the project and i the investment needed.

Total Risk Cost (TRB).

Every risk in the project needs to be quantified in a way that the monetary value that goes along with it becomes determined. Therefore the lowest possible impact, the probable impact and the highest possible impact are estimated and weighted for every risk:

$$\text{TRB} = \sum_r \frac{x \times li_r + y \times pi_r + z \times hi_r}{x + y + z} \quad (7)$$

where r represents the risks in the project, li the lowest possible impact, pi the probable impact, hi the highest possible impact and x, y and z the weights. Further explanations on the estimation and calculation of risk can be found in [BRA07].

Total Project Budget (TPB).

The three figures discussed summarize to the Total Project Budget.

$$\text{TPB} = \text{TLB} + \text{TIB} + \text{TRB} \quad (8)$$

or

$$\begin{aligned} \text{TPB} &= \sum_p \sum_s rate_{ps} \times demand_{ps} \\ &+ \sum_p \sum_i investment_{pi} \\ &+ \sum_r \frac{x \times li_r + y \times pi_r + z \times li_r}{x + y + z} \end{aligned}$$

Planned Value (PV).

This indicator is the baseline for Earned Value Methodology (see also [PMI04] p. 172–176 and [PMI05]) and the application of all budget related control mechanisms in a project. It is similar to the TPB but does not contain the risk budget. The reason behind is, that the PV is the basis all efforts within the project are tracked against – if risk cost would be included in this figure, non-occurred risks would be counted as success to manage the project below budget. Further the point in time for a possible incident cannot be determined a priori and therefore a valid cost plan could not be provided.

$$\text{PV} = \text{TLB} + \text{TIB} \quad (9)$$

or

$$\begin{aligned} \text{PV} &= \sum_p \sum_s rate_{ps} \times demand_{ps} \\ &+ \sum_p \sum_i investment_{pi} \end{aligned}$$

Total Effort (TE).

The total effort represents the timely effort invested in a project and is normally measured in man-years.

$$\text{TE} = \sum_p \sum_s demand_{ps} \quad (10)$$

where p represent the periods of the project and s the skills needed.

3.4 Building the quantification criteria

Obviously all of the factors determined ($P_m\text{B}\beta_1, \ldots, P_m\text{B}\beta_o$; $P_m\text{P}\beta_1, \ldots, P_m\text{P}\beta_q$) need to be used to prioritize a portfolio effectively. This introduces two new problems:

- a standardization of the β-figures is needed, as most of them have different measures and scales. This is close to impossible because how should e.g. "Customer Satisfaction" and "Education days of an employee" be measured on the same – still meaningful – scale?
- a weight for every β-figure needs to be calculated to be in the position to aggregate the factors to a significant indicator. The word "significance" implies already that the weights need to be derived from the attitude of the decision-makers. As there is more than one decision-maker in a team, a compromise would need to be made which is again a sub-optimal solution.

The problem can be solved by looking at the different β-figures neither considering their measurement nor their weights but still offering a transparent and comparable figure. The solution is in the calculation of the area that is spanned by the different relative β-figures in a a radar-chart (also called spider-chart) in figure 7.

The table for the base values looks as follows:

	Criteria				
	1	2	3	4	5
Project 1 abs.	50	200	80	150	100
Project 2 abs.	120	40	160	130	140
Project 1 rel.	42%	100%	50%	100%	71%
Project 2 rel.	100%	20%	100%	87%	100%

Using this type of representation has several advantages:

- Every figure can be presented using its measure – the only topic of importance is, that the scale is used in a way that the better the result is, the larger the distance to the zero-point of the graph needs to be.

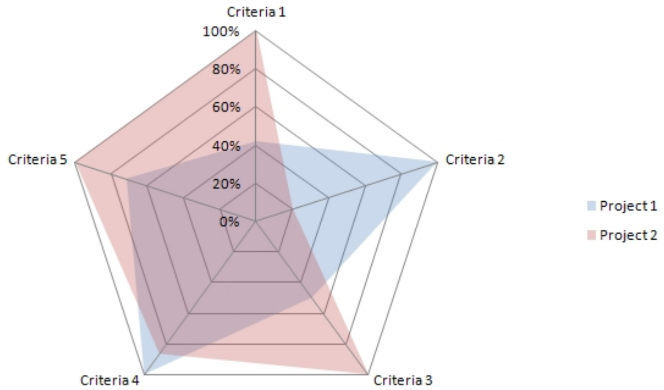


Figure 7: Sample radar chart using five different criteria

- It can be used for an arbitrary number of criteria larger or equal than three.
- The change of the scale does not change the result as all projects are measured against the same baseline.

In the next step the area needs to be calculated for each of the sample projects. To do so, the formula for calculating the area of a polygon is given by (see also [BOU98]):

$$\text{Area} = \left| \frac{1}{2} \sum_{i=0}^{N-1} (x_i y_{i+1} - x_{i+1} y_i) \right| \tag{11}$$

where N represents the number of edges in the polygon and x and y their coordinates. The last coordinate must be identical with the first one to close the area of the polygon.

To do the calculation with the items out of a radar chart, the data points need to be transformed into a two-dimensional co-ordinate system. In the first step x- and y-values of the data points are calculated taking the centre of the polygon to be the zero-point of the grid. This can be derived using trigonometric functions. Assuming – like shown in figure 7 – the line for criteria one is vertically aligned (what means 90 degree or $\pi/2$) the formula is defined as follows; let x_i and y_i be the x and y coordinates relative to the centre of the radar-chart for every relative value χ_i of the corresponding criteria β_i in the radar-chart where N is the total number of criteria:

$$x_i = \cos\left(\frac{\pi}{2} - \frac{2\pi\,(i-1)}{N}\right) \times \chi_i \tag{12}$$

$$y_i = \sin\left(\frac{\pi}{2} - \frac{2\pi\,(i-1)}{N}\right) \times \chi_i \tag{13}$$

The formula is derived the following way:

$$\begin{aligned} x_i &= \cos\left(\left(90 - \frac{360}{N} \times (i-1)\right) \times \frac{2\pi}{360}\right) \times \chi_i \\ &= \cos\left(\left(90 - \frac{360 \times (i-1)}{N}\right) \times \frac{2\pi}{360}\right) \times \chi_i \\ &= \cos\left(\frac{180\pi}{360} - \frac{720\pi \times (i-1)}{360N}\right) \times \chi_i \\ &= \cos\left(\frac{\pi}{2} - \frac{2\pi\,(i-1)}{N}\right) \times \chi_i \end{aligned}$$

The deduction is analogical for y_i. For the figures given in table 3.4, this gives the following coordinates and the area the projects cover:

		Criteria 1	2	3	4	5	Area
P1	x	0,00	0,95	0,29	-0,59	-0,68	1,15
	y	0,42	0,31	-0,40	-0,81	0,22	
P2	x	0,00	0,19	0,59	-0,51	-0,95	1,49
	y	1,00	0,06	-0,81	-0,70	0,31	

The result shows, what is expected when looking at figure 7: project 2 covers a larger area and has therefore the higher value compared to Project 1 in terms of measures that are influenced by it. As discussed already, this indicator can easily combined with the formula defined in (4) to calculate the value of an portfolio option based on all the projects contained.

3.5 Constraints within a project or a project portfolio

The last remaining issue not being addressed so far is the one of constraints within a project or a project portfolio. As a matter of fact limitations constrict the possibilities of projects to choose for a portfolio. Recent approaches try to formulate every constraint as a financial one arguing that anything else can be removed by monetary investments. In reality this is not the case as it was explained already in the description of weaknesses at the beginning of chapter 3 on the example of skills of human resources.

As discussed in section 3.3, all relevant indicators for the selection of projects are represented in the α- and the derived β-figures. This implies that also the relevant constraints for the portfolio can only hit one of these figures.

First of all, all the αs and βs from the projects and all their totals in case of combinations that could be started in t_0 based on their dependencies are summarized in a matrix together with their prioritization and constraints. The order of the projects is based on the total option value of the project (except for mandatory projects) summarizing all discounted option values it is the first project in. At the bottom of the matrix, all constraints for the indicators are filled in. Additionally every constraint needs to be marked, if the constraint must not be undercut (a minimum-constraint) or must not be exceeded (a maximum-constraint):

Project	Total Option Value	BSC Input $B\alpha_1$	$\dots$	$B\alpha_n$	Output $B\beta_1$	$\dots$	$B\beta_o$
P_1	ov_1		$\dots$			$\dots$	
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
P_m	ov_m		$\dots$			$\dots$	
	$\sum$		$\dots$			$\dots$	
Constraint			$\dots$			$\dots$	

The project-specific αs and βs are not displayed in this example for space reasons. Normally the matrix is extended at their right border by the project-specific αs and βs.

All totals of αs and βs need to compared with their respective constraints. For all of them which are violated, so called "discretionary" dependencies need to be added in the following way: the project with the lowest total option value is taken away from the portfolio of t_0 and given a dependency to the project finishing the earliest after the prioritization.

This is repeated until all constraints can be fulfilled. If this is impossible (so in the worst case, the project with the highest total option value cannot be executed) the topmost project causing the conflict is removed and the procedure is restarted with all the other projects. If this extended procedure does not direct to a meaningful portfolio, the constraints are too narrow to allow a prioritization. In this case, focus need to be set on widening the constraints.

3.6 The Final Portfolio

The portfolio developed is the one that contributes best to the strategic targets of the company under the given conditions. However, the prioritization itself is not a guarantor that the targets set for the projects are also achieved. For controlling the projects in a way to have tight control on the progress, there are methods available but they are outside of the scope of this paper – a detailed description can be found at [PMI05].

4. EXAMPLE: IMPLEMENTATION OF THE NEW APPROACH

4.1 Initial situation

This chapter deals with the exemplary implementation of the approach developed. The sample setup consists out of five projects taken out of a project portfolio of a bank:

#	Name
1	Data Warehousing (DWH)
2	Management Information System (MIS)
3	Customer Relationship Management (CRM)
4	Application Processing System (APS) for loans
5	Collection System (CS) for overdue loans

To fulfil the quantification requirements defined in section 3.3 the model needs to rely on a BSC developed for this company and on the respective input parameters to this BSC. The success factors defined for this sample BSC can be seen in figure 8.

The Cause-Effect model for this sample BSC is shown in figure 9. The detailed aggregation algorithms from the α-figures up to the calculation of the influence of the success factors is not discussed here in detail, as it is part of a BSC and for the algorithm in this example, only the input-figures and the output-figures of the BSC are of importance.

4.2 The distribution of the set of projects including their dependencies

Before the paper goes into detail on the α- and β-figures for this set of projects, the dependencies for this constellation are discussed. Following the formula given in (2), the complexity of five projects and their combinations give 31 possibilities to structure the portfolio in t_0:

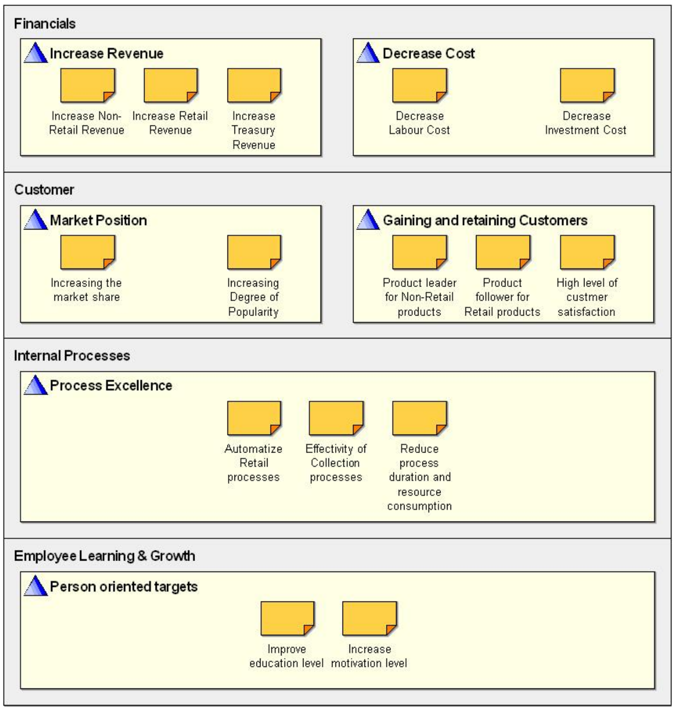


Figure 8: Success factors for the sample BSC – developed using ADOscore®

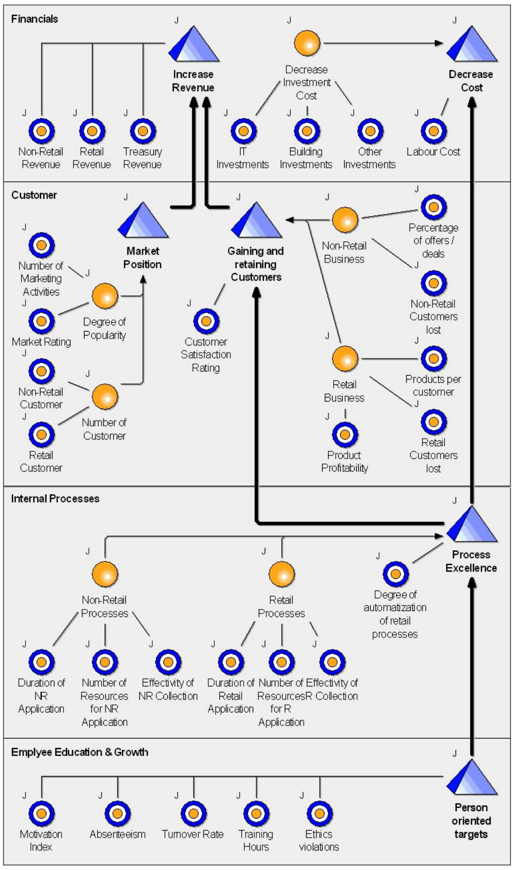
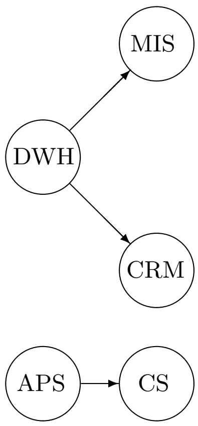


Figure 9: Cause-Effect model for the sample BSC – developed using ADOscore®

Combination	Possibilities
$\binom{5}{1}$	P_1, P_2, P_3, P_4, P_5
$\binom{5}{2}$	P_1P_2, P_1P_3, P_1P_4, P_1P_5, P_2P_3, P_2P_4, P_2P_5, P_3P_4, P_3P_5, P_4P_5
$\binom{5}{3}$	$P_1P_2P_3$, $P_1P_2P_4$, $P_1P_2P_5$, $P_1P_3P_4$, $P_1P_3P_5$, $P_1P_4P_5$, $P_2P_3P_4$, $P_2P_3P_5$, $P_2P_4P_5$, $P_3P_4P_5$
$\binom{5}{4}$	$P_1P_2P_3P_4$, $P_1P_2P_3P_5$, $P_1P_2P_4P_5$, $P_1P_3P_4P_5$, $P_2P_3P_4P_5$
$\binom{5}{5}$	$P_1P_2P_3P_4P_5$

In this example the MIS and the CRM project rely on the implementation of the DWH project; both systems are analytical ones and depend on various data loaded from different source systems. The APS project and Collection System project are independent from the DWH-project but the APS project is the mandatory predecessor for the Collection System (the bank could not collect overdue loans they do not have the data for). This information gives the following dependency map:



The dependency matrix for the projects is as follows:

Project	Dependencies
DWH	-
MIS	DWH
CRM	DWH
APS	-
CS	APS

Keeping the dependencies in mind the possible complexity of the portfolio reduces alreay from 31 to three possibilities in t_0 as defined in (3):

Combination	Possibilities
$\binom{2}{1}$	DWH or APS
$\binom{2}{2}$	DWH and APS

4.3 Quantifying measures

In our example the contribution to the input factors (already derived from α-figures) by the projects for the BSC were identified like this:

BSC Input Variables	DWH	MIS	CRM	APS	CS
Motivation Index					
Absenteeism					
Turnover Rate					
Training Hours	+1.600	+100	+200	+1.000	+150
Ethics Violations			-5		
Duration of NR Applications	-2			-5	
Number of Resources for NR Applications	-5			-10	
Efficiency of NR Collection	+5%		+5%		+10%
Duration of Retail Applications	-2		-1	-2	
Number of Resources for Retail Applications	-20		-10	-20	
Efficiency of Retail Collection	+5%		+5%		+20%
Degree of automatization of retail processes	+5%		+5%	+10%	+10%
Number of Marketing Activities	+25		+30		
Market Rating		+1		+1	+1
Non-Retail Customer			+100		
Retail Customer			+30.000		
Customer Satisfaction Rating	+1		+2	+1	-1
Percentage of offers/deals	+5%		+10%	+10%	
Non-Retail customers lost			-10		+5
Products per customer	+3		+3		
Retail Customers lost			-1.000		+500
Product Profitability		+10%			+5%
IT Investments	+500k	+100k	+150k	+150k	+150k
Building Investments	+100k				
Other Investments					
Labour Cost	+630k	+840k	+1.260k	+420k	+210k

The corresponding output figures (β-figures) for the BSC have been calculated and bring the results for the prioritization input:

BSC Output Variables	DWH	MIS	CRM	APS	CS
Person Oriented Targets	+16	+1	+2	+10	+2
Process Excellence	+28	+5	+7	+35	+7
Market Position	+25	+500	+430	+500	+500
Gaining and Retaining Customers	+500	+100	+610	+200	-5
Increase Revenue	1.568,6k	1.766,6k	2.049,0k	1.745,2k	1.503,4k
Decrease Cost	-1.306,0k	-957,0k	-1.416,0k	-575,0k	-393,8k

In table 4.3 it needs to be especially noted that the operational target of "Decrease Cost" has negative values as projects generate costs and therefore cannot contribute reducing their costs by themselves.

So far the BSC input- and output variables have been discussed. What is missing from the KPI point of view are the figures coming from the project input variables and their transformation to the output variables:

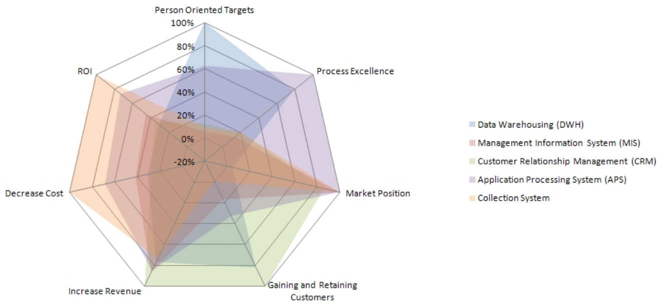


Figure 10: Radar-Chart for the data in the example

Project Input Variables	DWH	MIS	CRM	APS	CS
Rate: Skill 1	600	600	600	600	600
:	:	:	:	:	:
Rate: Skill s	1.500	1.500	1.500	1.500	1.500
Demand: Skill 1	800	400	600	200	100
:	:	:	:	:	:
Demand: Skill s	100	400	600	200	100
Investment Cost	600.000	100.000	150.000	150.000	150.000
Probability: Risk 1	10%	20%	15%	40%	30%
:	:	:	:	:	:
Probability: Risk r	50%	30%	10%	15%	10%
Impact: Risk 1	10.000	25.000	30.000	10.000	100.000
:	:	:	:	:	:
Impact: Risk r	150.000	40.000	15.000	8.000	38.000
Duration (in months)	12	8	10	18	12
Obligatory Project		Y			
Direct Dependencies		1	1		4
Operations Cost for 3 years	300.000	60.000	90.000	90.000	90.000

If those input figures become calculated by the formulas explained in chapter 3.3.2 the following output matrix can be determined – also for prioritization purposes, like the output matrix from the BSC:

Project Input Variables	DWH	MIS	CRM	APS	CS
Project Budget	1.306.000	957.000	1.416.000	575.200	393.800
thereof - Total Labour Cost	630.000	840.000	1.260.000	420.000	210.000
thereof - Total Investment Cost	600.000	100.000	150.000	150.000	150.000
thereof - Total Risk Budget	76.000	17.000	6.000	5.200	33.800
Duration (months)	12	8	10	18	12
Obligatory Project with dependencies	Y	Y			
Full Dependencies		1	1		4
Return on Investment (ROI)	128%	188%	145%	306%	418%

4.4 Building the quantification criteria

Of course the project budgets presented in this figure are equal with the negative decrease of cost in table 4.3. The χ-figures derived from the tables 4.3 and 4.3 are now used to build the radar-chart in figure 10. For the simplification of illustration not all criteria have been considered. The table with the base values looks as follows:

	POT	PE	MP	GaRC	IR	DC	ROI
DWH rel.	100%	78%	5%	82%	77%	30%	31%
MIS rel.	6%	14%	100%	16%	86%	41%	45%
CRM rel.	13%	20%	86%	100%	100%	28%	35%
APS rel.	63%	100%	100%	33%	85%	68%	73%
CS rel.	9%	20%	100%	-1%	73%	100%	100%

This data results in the following co-ordinates and values for the covered area:

		POT	PE	MP	GaRC	IR	DC	ROI	Area
APS	x	0,00	0,78	0,97	0,14	-0,37	-0,67	-0,57	1,48
	y	0,63	0,62	-0,22	-0,30	-0,77	-0,15	0,46	
CRM	x	0,00	0,15	0,84	0,43	-0,43	-0,27	-0,27	0,97
	y	0,13	0,12	-0,19	-0,90	-0,90	-0,06	0,22	
DWH	x	0,00	0,61	0,05	0,36	-0,33	-0,29	-0,24	0,83
	y	1,00	0,49	-0,01	-0,74	-0,69	-0,07	0,19	
CS	x	0,00	0,16	0,97	0,00	-0,32	-0,97	-0,78	0,79
	y	0,09	0,12	-0,22	0,01	-0,66	-0,22	0,62	
MIS	x	0,00	0,11	0,97	0,07	-0,37	-0,40	-0,35	0,40
	y	0,06	0,09	-0,22	-0,15	-0,78	-0,09	0,28	

Looking at the project itself without considering the possible portfolio options would clearly favour the APS project (1,48) compared to the DWH project (0,83). As described before the project on its own is not the driving factor – it is the option value of the different options that is important. Using equation (4), the results from table 4.4 and a discount rate of 5% shows the following results for the available options:

Option	Option Value
DWH	0,79
DWH - MIS	1,16
DWH - CRM	1,67
APS	1,42
APS - CS	2,13

Taking the projects being marked mandatory into the picture as well (see table 4.3) shows that the DWH-project needs to be executed for the MIS project having a obligatory status although the option DWH-MIS has the second-lowest value. Finally the following prioritization would be set:

Option	Mandatory	Option Value
DWH - MIS	Y	1,16
APS - CS		2,13
DWH - CRM		1,67
APS		1,42

The DWH-project is not given separately in table 4.4 as it is executed anyway because of the dependency.

In the next and also the last step the constraints need to be considered. Therefore a table is created as described in chapter 3.5. For the reason of clarity, the criteria already used in figure 10 and table 4.4 have been reused – the only difference to be noted is, that the ROI, the Increase in Revenue and Decrease of cost are removed but therefore an α-figure from the Project-αs is added: the demanded availability of a business analyst for the respective project measured in person days (PDs):

Project	Total Option Value	POT	PE	MP	GaRC	BA PDs
DWH-MIS	1,16	+17	+33	+525	+600	+550
APS-CS	2,13	+12	+42	+1.000	+195	+300
DWH-CRM	1,67	+18	+35	+455	+1.110	+500
APS	1,42	+10	+35	+500	+200	+200
	Total Constraints	+57 Min (+25)	+145 Min (+60)	+2.480 Min (+1.000)	+2.105 Min (+700)	+1.550 Max (+700)

The table shows an obvious conflict with the person days for the business analysts needed (BA PDs). Following the procedure described in section 3.5, the options need to be eliminated buttom-up following their total option values. If this is done in this portfolio, it ends up with the following status:

Project	Total Option Value	POT	PE	MP	GaRC	BA PDs
DWH-MIS	1,16	+17	+33	+525	+600	+550
	Total Constraints	+17 Min (+25)	+33 Min (+60)	+525 Min (+1.000)	+600 Min (+700)	+550 Max (+700)

The current status shows that the issue with the BA PDs could be solved but turned the project into conflict with lots of other constraints. Obviously the portfolio cannot be structured in a way that stay within the boundaries set. This leaves two options: the first one is, to take the portfolio above also implying that the stakeholders need to adapt the constraints given. The second option would be to include another project to optimize the number of limits being fulfilled and focus on adapting other limits:

Project	Total Option Value	POT	PE	MP	GaRC	BA PDs
DWH-MIS	1,16	+17	+33	+525	+600	+550
APS	1,42	+10	+35	+500	+200	+200
	Total Constraints	+27 Min (+25)	+68 Min (+60)	+1.025 Min (+1.000)	+800 Min (+700)	+750 Max (+700)

In the second option the constraint of the BA PDs is violated again with a very small backlog, which might be resolved. Therefore the other constraints could be kept and the portfolio could be adjusted in the best possible way. Most probably the company could resolve the BA PD issue and would go for the portfolio given in option 2.

5. CONCLUSION

The discussion in this paper showed that there are lots of improvements possible to extend the existing selection algorithms in a way to make them implementing the strategy of a company. If a company went already through the painful process of creating and implementing a BSC and is living the life-cycle process that goes along with it, the presented algorithm for the selection of appropriate portfolios is a spin-off product of the BSC and PPM. Naturally, the selection algorithm is only one part of various steps to successfully implement the strategy. Others, like the carefully planning and controlling of a project portfolio or the sustainable implementation of the project content are others that need to be dealt with seriously. Possible solutions in these fields are the Earned Value Methodology (EVM) for controlling the process or classical mechanisms for mid-term planing to compare the expected results from PPM with the realized benefits.

The challenge in the presented approach is definitely the quality of the BSC, the portfolio selection algorithm is based on. If the strategy is not described properly or the controlled measures are not the right ones to successfully achieve the vision of the company, the selected portfolio will fail the same way as the BSC will. Therefore the success of the implementation of this algorithm will heavily rely on the time that was spend for defining the strategy. This is also a lessons learned that should be taken away when project portfolios should be aligned with the strategy: the project portfolio can only be as good as the underlying strategy is.

The further steps for the PhD thesis will be the extension of the existing project portfolio life-cycle not only by the selection but also for the planning and monitoring phases. The target is to present a framework where the whole life-cycle is linked to the implementation of the strategy using BSCs. Further the scope is exclusively to focus on optimizing the project portfolio into this direction – it is true that projects that cannot be evaluated against their benefits but might deliver unexpectedly high results will never be selected with this methodology.

For the proof of concept (POC) data will be taken from an internationally acting bank and their project portfolio.

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