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Balancing the Costs of Human Resources on an ERP Project

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ABSTRACT

ERP projects cannot be completed without external consulting support due to insufficient expertise of internal resources. The need for external consulting during project execution could be reduced if the capabilities of internal resources are improved through team training that is provided before the commencement of a project. Previous studies demonstrate that the most cost-effective approach to ERP implementation is to balance formal initial team training with external consulting support. This paper expands previous research by adding a decision model that allows a manager to: (1) assess the impact of a training strategy on the accumulative weekly cash outflows, (2) forecast the performance and track the progress of an ERP implementation, and (3) calculate the amount and experience level of the consulting support required to reduce the duration of a project. Feedback from practitioners suggests that this type of tool would be welcomed by the project management community.

Subject Areas:

Decision Support Systems, Learning, Resource Management, Project Costing.

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1. Introduction

ERP implementations are complex IT projects which usually take between six months and two years to complete [1]. Before the year 2000, almost all ERP projects involved the implementation of a new system. During the last decade, a second category of ERP projects emerged, in which the previously installed systems were expanded or upgraded [2]. Some companies have pursued the development of their own in-house ERP solutions but on the majority of projects the packaged system from a software vendor is configured [3]. ERP consultants with specific industry knowledge assist the team of internal resources with the system configuration. If a system must be customized, contractors specializing in system development are also hired.

Formal team training in a classroom setting can be provided to the project team before the implementation. This training improves the capabilities of the internal resources and leads to the reduction of consultant involvement and costs [4-6]. During the implementation, the consultants transfer knowledge to the internal resources through on-the-job training. When the implementation is complete, the consultants can also be involved in training end users. This training is limited to the transactions processed by the respective business functions but does not explain the configuration of a system [7-9].

During an ERP project, external resources learn company processes and internal resources learn the new system so the capabilities and performance of both groups improve [10, 11]. Due to the lack of decision models that consider the correlation between performance changes and project parameters [12] it is difficult to accurately predict the degree to which external help is necessary [13]. In order to avoid the negative impact of uncertainty [14] managers tend to hire too many resources [15]. As a result, the cost of consultants on an ERP project often adds up to eight times the cost of a software alone [16]. To that end, the significant savings will be achieved if an impact

of training and performance changes on project parameters is analyzed during planning of ERP projects.

This paper discusses the impact of changes in a team's aggregated performance on the costs and duration of a project, which is multi-disciplined, requires an extended integration period, and is most effective when executed in a stable environment [17]. Note that system development projects wherein the contractors are paid based on output are not covered by this research. In Section 2, we argue that reductions in consulting support, the most expensive component of project costs, can be achieved if the project team is given more formal training. A decision model that can be used to support that argument is developed in Section 3.

In Section 4, we analyze two ERP projects implemented by Canadian and European companies. In Section 4.3 we address the following three research questions: (1) How much formal training should be provided before the commencement of a project in order to implement the system in a cost effective way? (2) How does training impact the schedule, output and baseline performance of a project? (3) What is the impact of consultants' experience and rate on project timelines and cost? Managerial insights are offered in Section 5. The limitations of our research are discussed in the concluding section.

2. Literature review

2.1. Consulting support versus team training

Although ERP software packages are used by thousands of companies world-wide, only one-sixth of all ERP implementation projects are completed on time and within budget [5]. Only 30% of all ERP projects are considered successful [18] and many of the projects have failed to deliver expected benefits [19]. ERP projects consume a large portion of company resources [4], thus it is

not surprising that many researchers have devoted their attention to the critical factors that lead to a successful implementation [3, 17, 20-22].

Project teams with high capabilities and experienced consultants are the primary contributing factors leading to successful implementations [5, 23], while inadequate training is associated with failure [24] and also has a negative impact on project duration [25]. A balanced project team is instrumental to any project [21, 26, 27] and must be assembled from the most knowledgeable employees in order to accomplish the required transformation [4]. However, an ERP project can rarely be completed by company personnel alone and requires consulting support [28, 29]. The number of consultants employed may be anywhere from four to 40, and in extreme cases, as many as 150 consultants can be involved [20].

Research shows that consulting fees are a significant part of project costs and together with the salaries of internal resources may add up to over 70% of all ERP costs [1, 28]. The extent of consultant involvement is different among each of the two project categories [30, 31]. For example, new system implementation projects are usually supported by a much larger number of consultants than system upgrades [28, 32], thus management must always carefully assess the use of external help and explore the ways in which its extent can be reduced to the absolute minimum [1, 28].

In order to limit consulting costs, companies turn their attention to various forms of training that can improve project team capabilities and internal readiness [7, 33]. For example, organizations have an 80% chance of success if at least 15% of the total implementation budget is reserved for formal training [34] and if knowledge transfer occurs during project execution [35, 36]. Firms that successfully assimilated a new system had invested approximately 15–20% of the

project budget into formal team training, while those that were less successful had spent only 10% or less [37, 38].

Formal training can take the form of standard courses available at training locations or customized training delivered at the company's site. The first form is cost effective only if a limited number of personnel are to be trained, since five-day course fees alone can be as high $4,000 per student. Even if all the expenses are not included and the wages of internal resources are not accounted for, the costs of training delivered in remote centers can add up very quickly. On the other hand, five-day fees of one consultant delivering training on site often costs between $8,000 and $10,000. Therefore, if more than three students are to be trained, companies prefer to arrange for in-house customized training by consultants instead [39].

2.2. Impact of training on project and team's performance.

Although it is relatively easy to justify the location of training, it is much more difficult to assess its impact on the team's performance during the execution of a project [38, 40]. For technology projects, a logistic function is recommended to track the non-linear changes in performance due to experiential learning, which takes place during formal and on-the-job training [41-45]. The logistic function accurately measures improvements in performance as a rate, in which a predefined output is completed [46-50]. In the case of an ERP project, the output can be defined as the number of ERP transactions processed in a unit of time [2]. Performance improvements are related to the performance ceiling through a learning curve coefficient, k [51].

Several models that measure performance are discussed in the literature [52-54]. Stummer et al. propose a competency model, in which each employee receives a profile consisting of competence efficiencies indexed using a catalogue [47]. Gutjahr suggests that the competency scores should be estimated by experts [48]. Coefficient k can be indirectly derived by retrofitting a learning curve

to a plot of the schedule performance index [55]. Learning curve coefficient can also be measured directly using an algorithm, in which the time required to complete a set of transactions is measured at the beginning and at the end of the formal training [56], or the time required to complete the data conversion procedure is measured at various times during the early stages of a project [52]. The algorithms for the direct assessment of k can effectively measure the impact of either formal or on-the-job training.

The value of k was examined by the extant research on various project settings [53, 57-59]. For example, in the experimental study of one-month projects executed by multi-skilled resources, the individual learning curves were established for internal resources assuming that a cross-skill or team-learning effect can be neglected and the efficiency of external resources is static. Since the employees were allowed to switch between different tasks, knowledge depreciation was expected and relatively low values of k (between 0.012 and 0.02) were used [57]. Since a team-learning effect in an ERP project is strong, a composite learning curve is required to assess the aggregated team's performance changes. However, knowledge depreciation can be neglected due to the lack of significant interruptions [32, 60, 61]. The external resources need to learn the company processes, so a static performance of consultants cannot be assumed [2]. As a result, relatively high values of k were recorded (between 0.6 and 0.9) [2, 56].

The performance function is critical during the development of a training strategy [4, 9, 17, 18, 62], which balances the cost of training with the costs of consulting support and allows sufficient time for formal training while avoiding unnecessary implementation delays [56, 63]. The various forms of training must be considered when such a strategy is evaluated. However, due to the lack of analytical tools, the evaluation of a training strategy is extremely time consuming and currently

impractical [56]. As a result, training is frequently underestimated and training budgets are often set too low [33, 39].

The Consulting Costs Model (CCM) which links training duration to implementation duration partially closes that gap [56]. CCM focuses on minimizing the cost of external resources and is best suited for cases where the cost of internal resources can be ignored. The model has four important limitations: (1) the impact of a training strategy on cash outflows cannot be evaluated, (2) the project baseline cannot be forecasted, (3) the number and level of resources required to reduce the project duration (compress the schedule) cannot be calculated, and (4) the application of the model in project management is limited due to unwieldy calculations required to balance training and consulting costs.

The analytical model developed in this paper (RCM) addresses the first, second, and third limitations of CCM. RCM consists of Resource Cost Formulas, a Baseline Equation and a Resource Requirement Equation. Resource Cost Formulas include all relevant costs of both internal resources and external consulting involved in an ERP implementation, such as: labor costs, travel costs and living expenses. In contrast to the previous model, the formulas can assess the impact of a training strategy on accumulative cash outflows and on the overall costs of a project. The Baseline Equation allows for the forecasting of an output in the form of the value to be delivered on a project over time. The forecasts are expressed in the same units as cash outflows to provide support for project control. The number and experience level of consultants required to deliver the project on a compressed schedule can be calculated using a Resource Requirement Equation.

The complex calculations required to evaluate and select a training strategy were the fourth limitation of a previous model. This paper offers not only a more robust decision support model

but also a Decision Support System (DSS), which simplifies the calculations required during the strategy assessment process. It automates the calculation of project duration and supports the full analysis of all human-resource costs associated with an ERP implementation.

3. Development of a decision support model.

3.1. Research methodology

Decision support systems (DSS) are software applications, which were designed to increase performance and improve the quality of decisions [64]. In this paper we present a model-driven DSS [65], which supports the development of a cost effective resource deployment strategy. The system is based on a conceptual model (RCM) developed from the application of learning curve theory [54, 66-68] to the management of ERP projects [3, 17, 69-71]. We follow a design science research methodology [72], which is based on the following design artifacts: constructs, models, instantiations, and methods [73]. The constructs, which are the foundation of RCM, include:

- A performance function is adopted from the learning curves research [43] and is discussed in section 3.2.1. The value of the learning curve coefficient ($k = 0.6 – 0.9$) is adopted from previous studies [2].
- Functional correlation between the duration of training and the duration of a project is adopted from the CCM [56] and is outlined in Section 3.2.2.
- The parameters of ERP implementation, such as: the duration of a project and formal training, as well as the amount and cost of project resources, are adopted from the literature on project management [74] and ERP implementation [3]. The parameters are explained in Section 3.2.3, in which a Resource Cost Formula is developed.

- The planned value (*PV*) equation, which is used by a standard project management methodology [59, 75, 76], is discussed in Section 3.2.4 where a Baseline Equation is produced.
- The correlation between the project duration and the number of resources [56], which is a starting point for the development of a Resource Requirements Equation, is outlined in Section 3.2.5.

The instantiation (i.e. the DSS developed in Section 3.3) provides key information, including team composition, experience level, project schedule, completion time and cash requirements [74, 77]. The artifacts were evaluated based on the combination of a case study and functional (Black Box) testing [72, 78]. RCM is an extension of CCM, so we followed the same method as used in the original study [56]:

- Step 1 – Gather the relevant data about the *primary and alternative strategies*. This step includes determination of the basic model parameters and parameter ranges.
- Step 2 – Calculate the *output* for the primary and alternative strategies. This step includes the assessment and comparison of strategies, including comparing the results of this research to those obtained in the original model.
- Step 3 – Conduct sensitivity analysis.

DSS was evaluated in an informal pilot study, during which three project managers were asked to comment on its utilitarian value using the following criteria [72, 79]:

(i) Functionality: translated as the ability to forecast project parameters under the condition of significant performance changes due to learning effects,

(ii) Completeness: translated as the ability to answer all questions regarding project performance under the condition of uncertainty, like forecasting project duration and

cost for various possible scenarios, including the variation in input parameters, assessment errors, etc.,

(iii) Ease of use: the speed at which the user can learn the system and how easy it is it to configure, deploy, and control its application,

(iv) Performance: the speed or capacity of the system when performing its function, and the accuracy and consistency of its output, and

(v) Fit with the organization: integration with commonly used project management tools and techniques.

3.2.Resource Cost Model

3.2.1.Performance Function.

The logistics function (L-curve) is recommended as a performance function, $P(t)$, for both categories of ERP implementations discussed in this paper [2]. It can be depicted by Eq. (1) if the maximum possible performance of a fully trained team $P_{100\%} = 1$ and the changes of team's abilities over time are represented by the learning curve coefficient, *k* (Figure 1).

$$P(t) = 1 - e^{-kt}$$

(1)

FIGURE 1 HERE

Research offers several methods, which can be used to measure *k*. [52, 55, 56]. For example, let's assume that *NT* is the number of transactions which can be completed in one hour. If *NT* was chosen as a measure of the team's ability to complete project tasks and the measurement was

conducted at time t^* from the start of a project, then the performance at that time was $P(t^*)=NT$ and $k = -\frac{1}{t^*}\ln(1-NT)$ [56][1].

3.2.2. Assumptions and formulas adopted from CCM.

The planning phase of an ERP project involves the mapping of business processes and uncovers the gaps against the proposed systems. During that crucial phase, management uses project control tools to establish the network of activities, to calculate the duration of activities, and to establish a critical path. After the network of activities is established, RCM can be used to calculate or adjust those durations and confirm/change a critical path. To that end, RCM can be either used on its own to plan/control a project or it can augment the currently available project management tools.

The model is developed under the following assumptions:

1. The resources are selected during planning and paid based on input. The model is based on a consolidated (team level) performance function, which does not change during the execution of the project [2, 56]. The other measures, such as the level of experience and the hourly rates are aggregated for the sub-teams from both internal and external resources. The turnover rate is low and it can be neglected. Interruptions to the project schedule are avoided and the parameters established during the planning period remain stable throughout execution [3].
2. The sequence of project stages is executed by the same core team, so the knowledge and experience required at any given phase depends on the knowledge accumulated during the previous steps. The impact of forgetting is not significant, so the parameters representing the deterioration of knowledge can be dropped from the progress curve [32].

[1] Note that the time units used to measure performance and project timeline can be and often are different.

3. For the implementation of a new system, the initial level of experience is low when compared to a performance ceiling and can be neglected. The implementation begins after the formal training is completed. For a system upgrade or expansion, formal training is not required and the initial level of experience is high when compared to a performance ceiling [2].

4. The gaps in a project timeline, such as the interruptions caused by technical problems, are not included in the analysis as they do not contribute to learning effects. If such gaps occur during project execution, they must be added to the project duration calculated from the RCM.

The above assumptions are similar to the CCM [56], from which we adopted the following concepts and equations:

1. The amount of project work is constrained. T_0 (planned duration) is the time required for fully trained resources to execute the project if they perform at 100% of their capability at all times. T_0 is deflated due to low performance during the early stages of a project. It must be extended by $\Delta T_I = T_I - T_0$, where T_I is an actual duration.
2. The extension of the planned duration, ΔT_I, depends on T_T (formal training duration), which is depicted in Eq. (2).

$$T_T = \frac{1}{k}\ln\left(\frac{1-e^{-k(T_0+\Delta T_I)}}{k\Delta T_I}\right) \tag{2}$$

Initial performance, P_0, after formal training can be found using Eq. (1):

$$P(T_T) = P_0 = 1 - e^{-kT_T} \tag{1a}$$

The duration of formal training required to reach P_0 can be calculated from Eq. (1a) as:

$$T_T = -\frac{1}{k}\ln(1-P_0) \tag{2a}$$

3.2.3. Resource Cost Formula.

The cost function, $C = C(T_T, T_I)$, is the starting point for the development of a model. It represents the sum of all costs associated with training and consulting decisions. In CCM, the cost function (Eq. (3)) is the sum of critical consulting costs incurred over one week (five working days). The cost function is depicted as the sum of the products of: the numbers of instructors (N_I), consultants (N_C),consulting managers (N_{CM}), and their daily rates (R_I, R_C and R_{CM} respectively).

$$C = C(T_T, T_I) = 5\{R_I N_I T_T + (R_C N_C + R_{CM} N_{CM}) T_I\} \tag{3}$$

In CCM, the costs of internal resources are not included, the costs such as travel or living expenses are not explicitly represented and the model does not support forecasting of weekly cash outflows. In contrast to CCM, the cost function in RCM (Eq. (4)) is the sum of all relevant costs and expenses of the internal and external team members participating in training and implementation.

$$\begin{aligned} C &= C(T_T, T_I) = \\ &= [N_I(5R_I + E_I) + N_S(5R_S + E_S)]T_T + \\ &+ [N_C(5R_C + E_C) + N_{CM}(5R_{CM} + E_C) + N_S(5R_S + E_S)]T_I\} \end{aligned} \tag{4}$$

where E_I, E_C, and E_S represent travel costs and expenses per week for instructors, consultants, and internal resources respectively; N_S is the number of internal resources involved in the project, and R_S is their average daily cost.

Any indirect costs, such as the cost of a workspace occupied by the project team, are below the model's materiality threshold and therefore are not included. Indirect costs are typically distributed as overhead costs at the end of a period. Training does not have any impact on the costs of hardware and software, so those costs are also excluded from the model. Similar to the CCM, T_0,

T_I, and T_T are estimated in weeks. When T_T is substituted from Eq. (2), Eq. (4) can be transformed into a Resource Costs Formula (Eq. (5)), from which the total cost of all resources participating in training and implementation can be calculated.

$$C(T_0 + \Delta T_I) = \\ = [N_I(5R_I + E_I) + N_S(5R_S + E_S)]\frac{1}{k}\ln(\frac{1-e^{-k(T_0+\Delta T_I)}}{k\Delta T_I}) + \\ + [N_C(5R_C + E_C) + N_{CM}(5R_{CM} + E_C) + N_S(5R_S + E_S)](T_0 + \Delta T_I) \quad (5)$$

For the implementation of a new system, a manager can use the graph of Eq. (5) to find the optimum extension of the planned duration ΔT_{Iopt}, that minimizes the total cost of all resources ($\min\{C(T_0 + \Delta T_I)\}$). The corresponding duration of training, which allows completion of the project within $(T_0 + \Delta T_{Iopt})$ can be calculated from Eq. (2) as follows: $T_{Topt} = \frac{1}{k}\ln(\frac{1-e^{-k(T_0+\Delta T_{Iopt})}}{k\Delta T_{Iopt}})$.

The manager can use Eq. (6), which is a modified form of the Resource Cost Formula, to forecast the accumulative weekly cash outflows.

$$C(T_0 + \Delta T_I) = [N_C(5R_C + E_C) + N_{CM}(5R_{CM} + E_C) + N_S(5R_S + E_S)]t \quad (6)$$

For the implementation of a new system, $t \in [T_T, (T_0 + \Delta T_I)]$, the cash flow during training can be assessed as: $C(T_T) = [N_I(5R_I + E_I) + N_S(5R_S + E_S)]t$, and the duration of formal training required to complete the project within the timeframe $(T_0 + \Delta T_I)$ can be calculated as:

$$T_T = \frac{1}{k}\ln(\frac{1-e^{-k(T_0+\Delta T_I)}}{k\Delta T_I}) \quad (7)$$

For a system upgrade or expansion, $t \in [0, (T_0 + \Delta T_I)]$ and when Eq. (2a) is substituted into Eq. (7), the initial performance which allows the project to be completed within $(T_0 + \Delta T_I)$ can be assessed as:

$$P_0 = 1 - \frac{k\Delta T_I}{1 - e^{-k(T_0 + \Delta T_I)}} \tag{7a}$$

3.2.4. Baseline Equation

The project baseline is a critical element in every project management system. Established during planning, the baseline is used to control a project. The standard systems, such as Earned Value Method (EVM) [59, 75, 80], do not accurately establish the baseline for ERP implementations [81]. CCM does not support the baseline calculation at all, which also limits its merit in project management. RCM addresses both limitations and offers a Baseline Equation that takes into account changes in performance due to learning and improves the effectiveness of project control.

The baseline for a project can be defined as a "planned value", PV, which is the projection of an output generated by a project. PV represents the costs budgeted for the work, which should be completed at certain given points in time [82]. Assuming that $t \in [0, T_0]$, the standard control system would project the costs budgeted for ERP implementation as:

$$PV = [N_C(5R_C + E_C) + N_{CM}(5R_{CM} + E_C) + N_S(5R_S + E_S)] * t \tag{8}$$

Since Eq. (8) does not consider the duration and the costs of training, it would have been more accurate to project PV from a Resource Cost Formula (Eq. (6)). Unfortunately, Eqs (6) and (8) are based on the assumption that the weekly output generated by a project should be the same as the weekly cash requirements, which is only valid for projects not impacted by learning. During an ERP implementation, the output delivered in the early stages of a project is significantly lower than the cash outflow due to reduced performance. To that end, although Eqs (6) and (8) can be used to project cash outflows and plan weekly cash requirements, the equations cannot accurately project the output of projects such as ERP implementations.

In order to account for the reduced performance in a project baseline, the performance function must be incorporated into the planned value projection, as depicted in Eq. (9):

$$PV_L(cat) = PV * \int_{T_T}^{T_T+t} (1 - e^{-k\tau})dt \tag{9}$$

where $PV_L(cat)$ is the forecast of the work, which will actually be completed during time *t*. $PV_L(cat)$ is expressed in budgeted costs , $cat = T_T$ for a new system implementation and $cat = P_0$ for an expansion of the existing system. After integration, Eq. (9) can be transformed into Eq. (10), which is the Baseline Equation for a new system implementation.

$$PV_L(T_T) = PV * [1 + \frac{1}{kt} e^{-kT_T} (e^{-kt} - 1)] \tag{10}$$

When Eq. (7a) is substituted into Eq. (10) we get:

$$PV_L(P_0) = PV * [1 + \frac{1 - P_0}{kt} (e^{-kt} - 1)] \tag{10a}$$

Eq. (10a) is the Baseline Equation for a system upgrade or expansion, for which training is not required.

Let's define a performance corrective coefficient [83], as $CPV(t, cat)$, where:

$CPV(t, T_T) = 1 + \frac{1}{kt} e^{-kT_T} (e^{-kt} - 1)$ and $CPV(t, P_0) = 1 + \frac{1 - P_0}{kt} (e^{-kt} - 1)$. When those are substituted into Eqs (10) and (10a), both equations can be transformed into the simpler format:

$$PV_L(cat) = PV * CPV(t, cat) \tag{11}$$

where $t \in [T_T, T_I]$ or $t \in [0, T_I]$ for the new system implementation and upgrade/expansion correspondingly, and PV can be substituted from Eq. (8).

3.2.5. Resource Requirements Equation

One of the key limitations of the CCM is that the model does not calculate the amount or experience level of resources required to reduce the duration of an ERP project. The approximate assessment is made from Eq. (12), which requires that the product of the project duration and the total number of resources is held constant.

$$T_0 * (N_C + N_S) = const \tag{12}$$

In order to reduce the duration of a project by the duration compression ratio TI, the project manager will have to increase the output generated by a project. The most obvious choice would be to increase the total number of resources by the resource index, $RI = \frac{1}{TI}$. For example, if an ERP implementation requires $(N_C + N_s) = (1+2) = 3$ resources in order to be completed in 12 weeks, and a project manager wants to reduce its duration to six weeks ($TI = 0.5$), he/she will have to increase the total number of resources by approximately $RI = \frac{1}{TI} = 2$, from three to six resources.

Eq. (12) is based on the same assumption as the project baseline, that the output generated on the project is equal to the projected cash requirements. As a result, the assessment is crude and does not take learning effects or experience into account. The Resource Requirements Equation developed in this section addresses those limitations. It uses a Baseline Equation (Eq. (11)) to project the costs budgeted for the work which will actually be completed (PV_L). Assuming that EI_C is an experience index and represents the aggregated consultants' experience level, and RI_C and RI_S represent the resource indexes of consulting and internal resources respectively, the project manager can increase the output generated by the project and therefore reduce its duration ($TI<1$) by increasing the number of resources ($RI_C>1$ and/or $RI_S>1$) and/or using the more experienced consulting resources ($EI_C>1$). Since planned value

(*PV*), calculated from Eq. (8), is the projection of costs budgeted for the work that must be completed, the goal is to equate the projection of work to actually be completed in the reduced-duration project with *PV*:

$$PV_L(T_0 * TI, R_c * RI_C * EI_C, RI_S * R_S, cat) = PV(T_0, R_C, R_S) \tag{13}$$

After substituting Eqs (8) and (11) into Eq. (13), it can be transformed into:

$$\begin{aligned}&[N_C RI_C * EI_C(5R_C + E_C) + N_{CM}(5R_{CM} + E_C) + N_S RI_S(5R_S + E_S)] * T_0 * TI * CPV(T_0, cat) = \\ &= [N_C(5R_C + E_C) + N_{CM}(5R_{CM} + E_C) + N_S(5R_S + E_S)] * T_0\end{aligned} \tag{14}$$

Eq. (14) can be rearranged to give:

$$\begin{aligned}&RI_C * EI_C = \\ &= \frac{N_C(5R_C + E_C) + N_{CM}(5R_{CM} + E_C) + N_S(5R_S + E_S) - [N_{CM}(5R_{CM} + E_C) + N_S RI_S(5R_S + E_S)]TI * CPV(T_0, cat)}{N_C(5R_C + E_C)TI * CPV(T_0, cat)}\end{aligned} \tag{15}$$

The Resource Requirements Equation (Eq. (15)) is a more accurate counterpart to Eq. (12). It allows a manager to find the required number of consulting resources that must be added to a project in order to shorten its duration. Its practical application is illustrated in Section 4.3.3. Assuming that *CI* represents an increase in the consulting rate, which covers an increase in the experience level EI_C, the additional cost required to cover a reduction in project duration can be calculated from the Resource Cost Formula (Eq. (16)), which completes the RCM model.

$$\begin{aligned}&C(T_0 * TI) - C(T_0) = \\ &= [N_C RI_C(5R_C * CI + E_C) + N_{CM}(5R_{CM} + E_C) + N_S RI_S(5R_S + E_S)] * T_0 TI + \\ &- [N_C(5R_C + E_C) + N_{CM}(5R_{CM} + E_C) + N_S(5R_S + E_S)] * T_0\end{aligned} \tag{16}$$

The manual calculations required during the analysis of costs are extremely time-consuming. The cost must be derived for the various ranges of possible extensions to the planned duration and not just for ΔT_{Iopt}. The calculations have to be repeated for the various implementation scenarios,

and therefore for different planned durations, numbers of consultants, numbers of internal team members, and daily rates.

In order to streamline the required analysis, we developed a user-friendly Decision Support System (DSS), in which the required information is presented in a wide selection of graphical and tabular reports.

3.3. DSS

The objective of a DSS is to present decision-makers with necessary information for a variety of recurring situations [1, 84] and to allow for the modeling of different perspectives of a complex phenomenon [85]. Donzelli reported that although decision support systems have extensively been used in areas such as accounting, finance, marketing, and new product development, their use in project management has been relatively recent [86]. The study from 2008 also observed the scarcity of DSS tools for project management and recommended an approach that will help software developers in various phases of a project, such as staffing and scheduling [87]. Ghasemzadeh and Archer highlight the need for decision support specifically for project control [88]. The prototype of a DSS discussed here is a Microsoft Windows application developed using Visual Basic, Access, and Excel. The prototype's functional architecture comprises of three modules: Strategy Definition, Strategy Analysis, and Reporting (Figure 2).

FIGURE 2 HERE

The Strategy Definition module is a primary user interface. It allows the user to select or modify the existing strategy or define a new strategy. It contains the following mandatory fields:

- Scenario Description (Strategy Code, T_0, and k) and
- Costing Info ($N_I, N_C, N_{CM}, N_S, R_I, R_C, R_{CM}, R_S, E_I, E_C$ and E_S).

The user has to either (1) modify the range for $DT_I = \frac{\Delta T_I}{T_0}$, which is predefined as [0; 10%] of T_0 (the corresponding range for ΔT_I will be calculated as $\Delta T_I = DT_I * T_0$), or (2) define the upper range for ΔT_I, from which the range for DT_I will be calculated.

The Strategy Analysis module provides data entry and preference screens including:

- Report type (Strategy Assessment is the default),
- The format for the required output (Tabular is the default), and
- The level of analysis (Total Cost is the default).

The output can represent either:

1. Total Resource Cost, where Eqs (5) and (2) are used to depict the relationship between the various project extensions, ΔT_I, along with resource costs and the duration of training,
2. Accumulative weekly cash outflows calculated from Eq. (6),
3. Baseline Graphs calculated from Eqs (8) and (11), or
4. Resource Adjustments Graphs calculated from Eqs (15) and (16).

The Reporting module can either provide the required output in tabular format or arrange the dataset to be imported into Excel for further processing. The following reports are available: Strategy Assessment (in tabular format only), Baseline Forecasting (in graphical format only), Strategy Comparison, and Sensitivity Analysis. Strategy Comparison facilitates the comparison of up to three different candidate strategies with the currently defined strategy. The impact of k on cost variation is calculated in Sensitivity Analysis, in which the user has to specify the range for k ($\pm 10\%$ is the default).

4. Case illustration

4.1. Introduction

The practical aspects of DSS will be illustrated using two ERP projects completed by manufacturing companies operating under the make-to-stock production strategy. We will refer to them as Case Organization A (COA) and Case Organization B (COB). The management of both companies was willing to invest in training, but due to resource limitations, a large number of internal staff could not be shifted to the project in either of the organizations, thus the management had to look for alternative training and knowledge-transfer strategies. The main motivation for the ERP system was to replace legacy applications, which could not support the dynamic expansion of both organizations. COA and COB believed that their core business processes were unique and that the system would have to be adjusted down the road. Indeed, the expansion projects were undertaken four and five years later in COA and COB, respectively. Exposure to technology, the approach to the ERP system, the composition of an implementation team, and the ERP experience were similar among the two companies when the decision to improve the systems was made. To that end, COA and COB had similar learning curves. Thus the learning curve coefficient for the system implementation was assessed as 0.6. For system expansion, 60% was assumed to be the initial level of experience and 0.9 was the chosen learning curve coefficient.

Users understood the importance of the ERP projects, accepted the system without major resistance, and both companies reported their successful completion. The CEOs in both companies were actively involved in the projects and they wanted to implement the systems as quickly as possible. The exploration of fast track options was equally important for both companies.

We will use the new system implementation at COA, which was also examined by previous research, to compare and contrast CCM and RCM and to discuss the first research question. All three research questions will be examined using the project executed at COB in 2010. ERP expansion at COB is a good example of a focused follow-up project, which must be executed by many companies in order to properly manage and fully utilize the information collected by their ERP backbone systems.

4.2. Background

4.2.1. Case Organization A (COA) [56]

COA is a Canadian food manufacturer, which at the time of ERP implementation had 750 employees and approximately CD$100 million in total sales. The company implemented four packages of the BAAN ERP system. Project A1 was planned as a standard ERP implementation, whose main objective was to improve financial reporting and prevent Y2K issues. Project A2 was executed four years later and its objective was to expand and optimize the functionality of the previously installed system. The Project A1 team consisted of eight internal resources, four consultants, and a part-time consulting manager assigned to the project. The planned duration for the **Primary Strategy 2:1**[2] was assessed as 56 [weeks], which placed the forecasted completion of the project only a few months prior to January 2000. The Steering Committee fully understood that ERP projects were often delivered with significant delays, so the risk of not being able to make the required transition before January 2000 was also significant. Therefore, the committee agreed to consider the three rapid implementation strategies (**Optional Strategies 1:1, 2:1,** and **3:1**)[3] under

[2] 2:1 represents the ratio of internal resources to consultants (external resources).

[3] It has been determined from Eq. (12) that in order to reduce the duration to 14 weeks, the total number of resources for the rapid implementation strategies would have to be increased from 12 to 48: $T_0 * (N_C + N_S) = const$ => $56 weeks * (4+8) resources = 14 weeks * 48 resources$. The company decided to split the total resource requirements using the following three ratios of internal to external resources: 1:1, 2:1 and 3:1.

the condition that they would not take longer than 14 weeks. The condition was imposed to limit the impact of transferring the high number of internal resources required to support such an aggressive schedule from their current duties. The company used the same eight internal resources on Project A2.

4.2.2. Case Organization B (COB) [89]

COB is a European company, located in the Czech Republic. It was established in 1992 and has grown to a modern company with 200 employees, taking a leadership position in their field. COB produces and distributes agricultural machinery. The two separate DOS-based legacy systems for accounting and production control could not support such a rapidly growing business. In January 2005, the company implemented ALTEC Aplikace, an ERP system developed by a European vendor. During the ERP implementation (Project B1), Finance, Commerce, Logistics, Production Control, Asset Management, HR, MRP, and Production Planning were implemented at once. Five years later, the decision was made to expand the system and implement Business Intelligence (BI). The BI Project (Project B2) was executed by six internal resources. The planned duration for the P**rimary Strategy 1:0** was assessed as 36 [weeks]. We will consider two **Optional Strategies** (**2:1, 3:1**), where duration would have been reduced to 24 [weeks] if three consultants were involved or reduced to 27 [weeks] if only two consultants were hired.

4.2.3. Summary of the case data

The projects' details are presented in the first part (first six rows) of Table 1. The results presented for Project A1 in the second and third parts of Table 1 were derived from the RCM (Strategy Assessment report) and CCM (Table 3 in [56]) respectively. The results for Project B2 were derived from the RCM.

TABLE 1 HERE

The selected projects provide enough detail for the full analysis of all human-resource costs associated with ERP implementations, and represent typical settings for the two project categories discussed in this paper. The impact of a learning curve on Project A1 was expected to be distinct but not as strong as for the more aggressively scheduled and staffed Project B2. Therefore, the benefits of improving the forecast accuracy as demonstrated for Project A1 are conservative when compared to the more aggressive timeframes required by Project B2.

The next section discusses the analysis of both projects, which is supported by the DSS developed in this paper. The four strategies for Project A1 are assessed and the first research question is addressed using reports based on the Resource Cost Formula in Section 4.3.1. The assessment leads to elimination of the least cost effective option. The second research question is answered in Section 4.3.2, in which the Baseline Equation is used to evaluate the cash outflows and project output for Project 2. In Section 4.3.3, the third question is discussed and the Resource Requirements Equation is used to calculate the number of consulting resources for **Optional Strategy 2:1** on Project B2. In Section 4.3, the potential contingencies for **Optional Strategy 2:1** on Project B2 are assessed using Sensitivity Analysis.

4.3. Analysis of the case

4.3.1. Assessing the Cost Effectiveness of Strategies

The cost-effectiveness of the **Optional** and the **Primary Strategies** can be analyzed from the Strategy Comparison graphs. The graphs depicted in Figure 3a were generated for Project A1 from the RCM. In Figure 3b, similar graphs were generated assuming only the costs considered by a previous model (CCM). Note that the results in Figure 3b are the same as those presented in the original source (Table 3 [56]). The graphs in Figure 3c were generated from the RCM for Project B2.

FIGURES 3a, 3b, 3c HERE

The duration of the training required for the completion of both projects within the total duration, $T_I = T_0 + \Delta T_I$ can be determined from Figure 4.

FIGURE 4 HERE

The results lead to the following conclusions:

(i) The combination of on-the-job and some formal training is the most cost-effective approach to an ERP project. For example, in the case of the **Optional Strategy 1:1** the minimum resource cost is achieved if two weeks of training are provided (Figure 4a). Extreme strategies (none or extensive formal training) prove to be more expensive than a balanced approach. It is interesting to note that if a project manager can sufficiently extend the project, formal training is not required at all, but that option is more expensive than a combination of formal and on-the-job training. For example, if on the Primary Strategy of Project A1 no formal training is provided ($T_T = 0$), the project duration needs to be extended by $\Delta T_I = 1.6$ weeks and the project cost is greater than for the optimal training duration $T_T = 0.9$ week (Figures 3a, 4a). On the other hand, the duration of the project does not need to be extended if approximately four weeks of formal training is provided, but that option is again more expensive than for the optimal training duration.

(ii) The resource ratio has an impact on project costs and the duration of formal training, which yields the minimum project costs. For example, **Optional Strategy 1:1** is the most expensive of all rapid alternatives, while **Optional Strategy 3:1**, which requires that a large number of internal resources are shifted to the project, is the least expensive. The minimum cost of **Optional Strategy 1:1** is achieved when two weeks of formal training are given, while **Optional Strategy 3:1** requires less than one week of formal training to complete the project at the lowest cost.

(iii) The cost of internal resources has a significant impact on the total costs of a project so the analysis based on a simplified view of costs can project distorted results. Although the duration of formal training has a very similar effect on the project extension when only consulting costs are considered, it has a much stronger impact on the project costs when all costs are included (trends in Figure 3a are steeper than in Figure 3b). For example, in Project A1: **Optional Strategy 2:1** seems to be less expensive than the **Primary Strategy 1:1** when only consulting costs are used for analysis but when all costs are considered it turns out to be more expensive.

(iv) If the cost of internal resources is not considered, then the balanced combination of "formal/on-the-job training" is skewed toward the longer formal training durations. The effect is more obvious in rapid implementation projects, where a significant number of internal resources are involved. For example, a one week extension of the project duration (7% increase), which requires less than a week of training, reduces the total costs of **Optional Strategy 2:1** for Project A1 from $3,500,000 to $3,220,000 (8% less). If the costs of internal resources are excluded, then a longer training period seems to be more cost effective (Figure 3b).

4.3.2. Evaluation of Cash Outflows (PV) and Project Output (PV_L)

The cost of a rapid-implementation is often higher than the cost of a primary strategy. Additionally, the cost is also distributed across a shorter implementation timeframe. In order to avoid cash flow problems, a manager must answer a second research question and review a Strategy Comparison report, in which the accumulative weekly cash outflows (Resource Cost Formula) is plotted against the baseline performance (Baseline Equation). In Figure 5, the Strategy Comparison report was generated for Project B2.

FIGURE 5HERE

The accumulative costs are depicted by dotted lines while the accumulative weekly output, which will be delivered by an "on schedule" project, is depicted by the continuous lines. The reduction in productivity caused by learning effects is represented by the gap between the accumulative cost (PV) and output (PV_L) graphs. That gap would be interpreted by any standard project management system as a delay in the project schedule. In Figure 6, the gap is calculated as $\frac{PV - PV_L}{PV} = 1 - CPV(t) = \frac{e^{-kT_T}(e^{-kt} - 1)}{kt}$ and is plotted as a function of time elapsed on the project.

FIGURE 6 HERE

The gap is the largest during the initial stages of a project. If a manager does not understand what causes that gap, then he/she will try to compensate for the reduced productivity assuming that the project is behind schedule. For example, the manager might add more resources to a project, which in turn would increase costs.

4.3.3. Adjusting Consulting Resources

The number of consultants can be calculated from the resource ratio, which is established using the Resource Cost Formula and the Baseline Equation. However, in order to properly assess the cost effectiveness of various levels of consulting resources and answer the third research question, the graphs based on the Resource Requirements Equation must also be generated since the graphs allow a manager to adjust the number and experience level of consulting resources.

For example, the rapid implementation of Project B2 (**Optional Strategy 2:1**) reduces the duration from 36 to 24 weeks ($TI = 0.67$). Project B2 must be completed by six internal resources ($RI_S = 6$), so three external resources must be hired to achieve the 2:1 ratio. The analysis demonstrated that **Optional Strategy 2:1** could be accomplished in 24.5 weeks ($\Delta T_I = 0.5$ if P_0= *60%* - Figure 4b) and would cost $918,000 (Table1).

In order to revisit the feasibility of **Optional Strategy 2:1** let's assume that the company will hire the consultants at an aggregated experience level ($EI_C = 1$). When all the parameters are substituted into Eq. (15), we get $RI_C = 1.03$, so the number of consulting resources should be $N_C RI_C = 3 * 1.03 = 3.09$ instead of the three consultants calculated from Eq. (12). The slightly higher number signifies the impact of reduced performance at the beginning of a project, which is not considered in Eq. (12). The higher number corresponds to the necessity of either extending a project by adding $\Delta T_I = 0.5$ week, or adding overtime at the amount of 9% of the cost of one consultant on the 24-week project, if the project must be completed within the 24-week timeframe. When the adjustment is taken into account, the additional cost of $16,981 must be added to the cost depicted in Table 1 (Eq. (16)). Those results are illustrated in the plots generated from a DSS (Figure 7), in which the required cost adjustments for **Optional Strategy 2:1** for Project B2 is plotted as a function of TI, assuming that a 20% increase in experience levels can cost 15% or 25% more than the original consulting rate ($CI \in \{1.15;1.25\}$).

FIGURE 7 HERE

In Figure 8, the required increase in the number of consulting resources, RI_C, is plotted as a function of TI, assuming that consultants at two different levels of experience can potentially be hired ($EI_C = 1$ for a current level and $EI_C = 1.2$ for 20% more experienced staff).

FIGURE 8 HERE

The results are surprising as they demonstrate that if four full-time and one part-time consultant are hired instead of three ($RI_C = 1.5$), then the project can be completed within nineteen weeks ($TI = 0.8$ in Figure 8) and costs $918,000 (Table 1) plus $16,981 (Figure 7). However, the project can be completed within twenty two weeks by six internal resources, four

full-time and one part time consultant if 20% more experienced consultants are hired ($TI = 1$ and $RI_C = 0.9$ if $EI_C = 1.2$). The second scenario costs $918,000 (Table1) minus $6,226 (Figure 7). In summary, assuming that the rate of more experienced resources is no more than 15% higher than the original consulting rate, the project costs less if a smaller number of more experienced consultants are hired (plots for $CI = 1.15$ are below plots for $CI = 1$). Therefore, it is more beneficial to hire the most experienced resources even if their hourly rates are higher. Additionally, since the cost of internal resources is inversely related to the duration of formal training that minimizes the project cost (the minimum cost in Figure 3b is to the left of the corresponding minimum cost in Figure 3a), the company should only provide formal training to the less expensive junior resources, while the more expensive senior resources should "learn on the job" (Figure 7).

All of the reports presented so far provide a manager with sufficient information to select the most suitable strategy, depending on the financial criteria for a project and the maximum number of internal resources available. However, the manager should also calculate the tolerance limits for the required costs and training durations, and explore the effect of any variability in the key parameters, especially the learning curve coefficient k.

4.4. Sensitivity analysis

Sensitivity analysis is usually performed to investigate the impact of changes in the key variables and parameters on the robustness of a solution [90]. The planned project duration T_0 and the learning curve coefficient k are the key parameters in the cost formula, and T_0 is usually established with the input from a software vendor. The impact of changes on the results calculated by the system can be analyzed from a Strategy Comparison report.

The learning curve coefficient is usually assessed from tests conducted either during training or in the very early stages of a project. Assessment errors can result from the testing methodology, previously unexpected exposure to the ERP system, or other factors. Therefore, the manager should define the range within which k might vary in a Strategy Definition module, and then analyze the corresponding tolerance limits for the resource costs. As an example, in Figure 7 we assumed the tolerance level for k to be $\pm 10\%$ of the coefficient value and included the graphs for the upper and lower tolerance limits.

Based on the sensitivity analysis, the project manager must allow for the following contingencies. The total cost of **Optional Strategy 2:1** for Project B2 ($918,000 – Table 1) should be adjusted on average by additional $16,981 to compensate for the reduced Initial Performance. The error of that adjustment will be in the range of [$13,846; $21,951] if $k = 0.9$ remains within 10% tolerance limits. The range can be translated into a $\pm 0.1\%$ margin for the total project cost.

5. Managerial insights

The balanced combination between durations of training and implementation for any given resource ratio can be found on the cost curve (Figures 3 and 4). However, in order to establish the most desirable ratio between internal and external resources, the constraints such as the maximum number of internal resources which can effectively support the project must also be considered. Those constraints are best analyzed through iteration of project parameters and ratios.

For the first iteration, we suggest that the manager selects the resource ratio to be within the range of 1:1 and 3:1. A ratio smaller or equal to 1:1 significantly increases costs while a ratio equal to or larger than 3:1 forces the company to remove a large number of internal resources from their routine duties in order to staff the project. **Primary Strategy 1:0** does not require any consultants

so it is the least expensive alternative. However, the ratio 1:0 should only be considered for system upgrades or expansion since it is feasible when internal resources are experienced.

The manager might want to adjust the ratios using fractions in order to narrow the range for the second iteration. For example, if only a few internal resources are available during the project, the manager might want to examine the cost effectiveness of a ratio lower than 2:1. Under such circumstances, he/she will use 0.5:1; 1:1 and 1.5:1 as the ratios of internal to external resources instead of 1:1, 2:1 and 3:1 used in our case study. The ratio can be fine-tuned based on the graphs included in Figure 7, which can also be used to calculate the necessary contingencies. Those graphs can be used to improve the planning of human resources and to protect the company from over-budgeting.

Since the contingencies are usually built around the baseline, the manager must exercise caution when using the standard system since it can provide overinflated forecasts. For example, if a manager uses Eq. (8) instead of Eq. (11) to control the execution of a project, he/she may incorrectly assume that the project is late and that more resources should be added to finish the work on time.

Due to the limitation of a two-dimensional Cartesian system, training duration T_T, which is a variable in Eq. (11), is fixed as a coefficient in Figure 5. The coefficients such as project parameters (daily rates, learning abilities, performance levels, etc.) and fixed variables allow to analyze a strategy at a given point in time. Their impact can be investigated through iterations. Note, that for the implementation of a new system the project begins after the training is complete so the independent variable in Eq. (11), t, must be kept within the following limits $T_T < t \leq T_I$.

We asked three practicing project managers for an informal evaluation of DSS. At the time of writing, the managers were employed by the Canadian division of a global company. Each of those

managers implemented at least one ERP system, and one developed several extensions to SAP. Their feedback is summarized below:

(i) As a proof of concept, DSS fulfilled its purpose of providing assistance to project managers. The results presented in Strategy Assessment report are in general agreement with trends observed during an ERP project.

(ii) The managers appreciated the various types of reporting options and the clearly defined method. However, two independent sources suggested adding a graph, in which the cumulative weekly project costs for different schedules can be compared.

(iii) The managers were able to use the system after a 30-minute introductory session.

(iv) DSS provides a more accurate prediction of project duration, but the accurate assessment of learning abilities is paramount. The results are consistent with testing and are promptly received because the system is simple and straightforward.

(v) The key suggestion, repeated in all feedback we received, was to integrate DSS with the standard Project Control System and to make sure that the algorithm and variables used by DSS follow the standard project management terminology.

To address the above comments, we decided to add a tutorial to the system and explain how it can be used to manage the two categories of ERP projects. We are also planning to conduct a formal evaluation, in which functionality, completeness, ease of use, performance, and fit with the organization will be evaluated using a 7-point Likert scale.

6. Conclusions

Assessing human resource competence and training needs is critical for a successful ERP project [91]. Although training itself can become a large project expense, this research suggests that a project manager should raise the capabilities of internal resources through training in order to

reduce the cost of consulting support. However, a project manager must carefully consider the type, duration, and timing of training in order to make sure that the costs of training and consulting support are balanced, as demonstrated in this and previous studies. The DSS developed in this study provides the support required during that process.

The value of DSS can be assessed based on the number of decisions improved and the value of each improved decision [10]. The DSS discussed in this paper automates the time-consuming and repetitive calculations involved. The project manager can use the DSS to closely examine the cost-effectiveness of training, to improve the accuracy of project duration forecasts, and to explore various human resource options for the new ERP implementation or the expansion/upgrade of the previously implemented system. As demonstrated in the case study, although the number of decisions improved is small, their value is significant.

The three practical limitations of the system are: (i) it can only be used on projects wherein resources are paid based on input, thus outsourcing or subcontracting is not covered by the model, (ii) it does not allow managers to recalculate the duration of a critical path if the number of resources is changed during the project execution, which means that it cannot be applied in situations where the turnover rate is high, and (iii) the impacts of various methods of establishing the value of the learning curve coefficient, k were not fully explored. We will address the first two limitations in subsequent versions of the model, which will be extensively evaluated by a panel of experts before the decision to commercialize the system is made. A more extensive empirical study is required to overcome the third limitation, which necessitates designing a suitable way to assess k in the early stages of a project and then reevaluating the coefficient during its execution.

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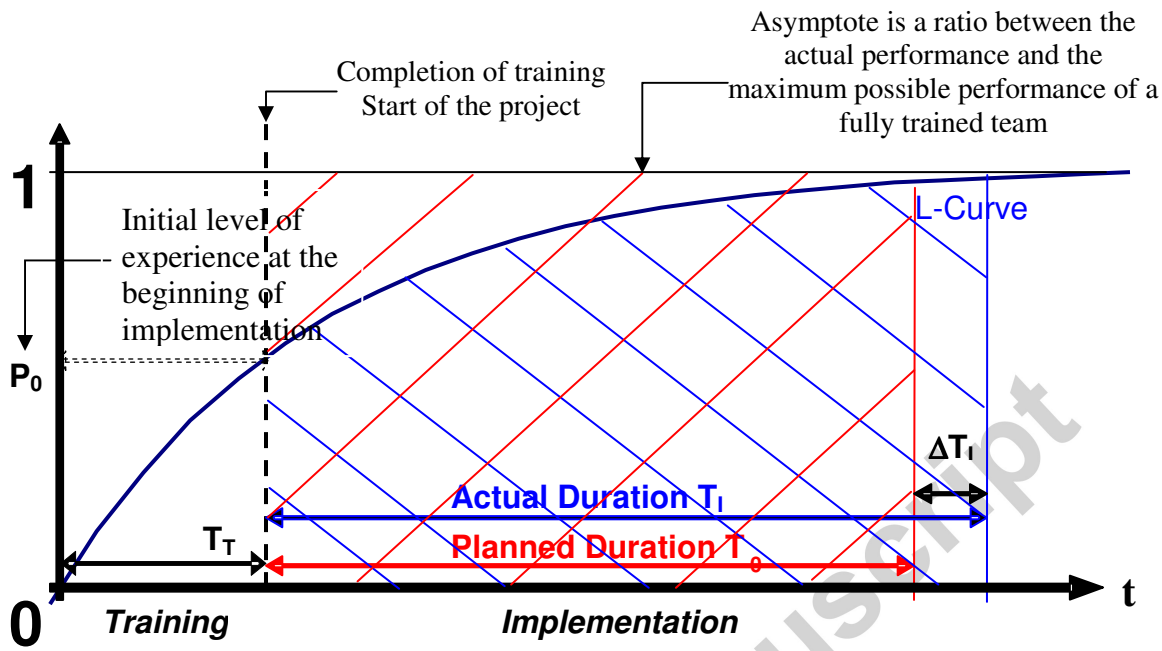


Figure 1. Performance Function

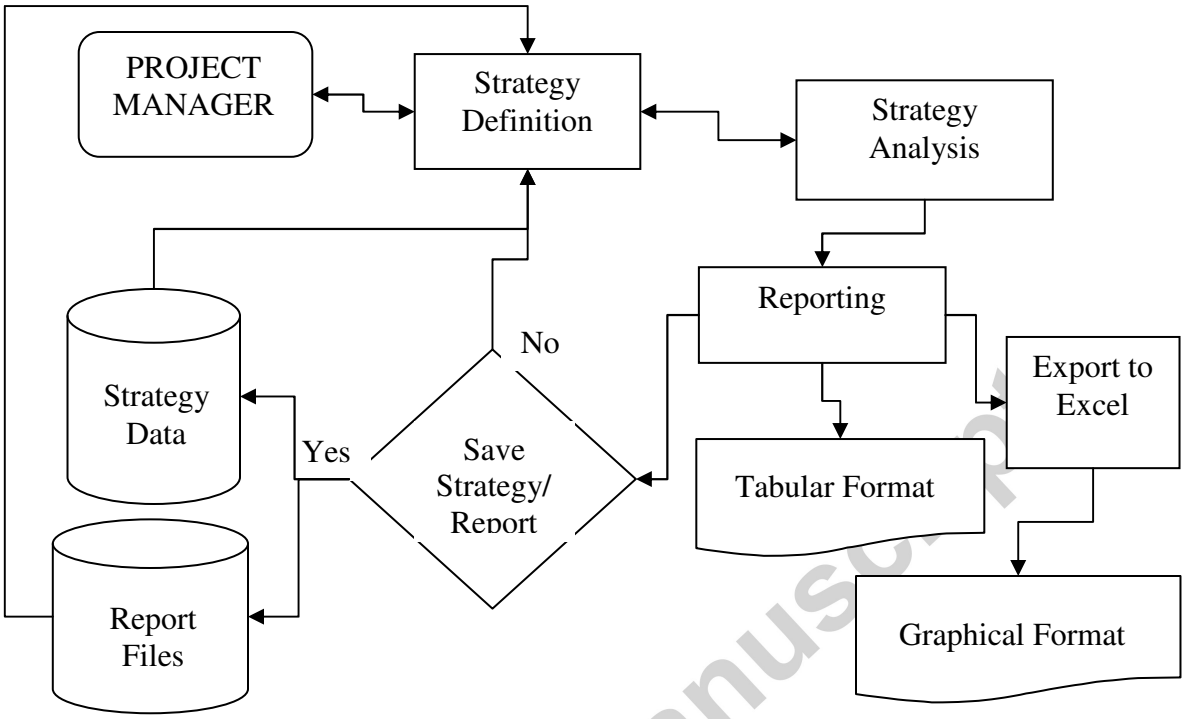


Figure 2. DSS application architecture

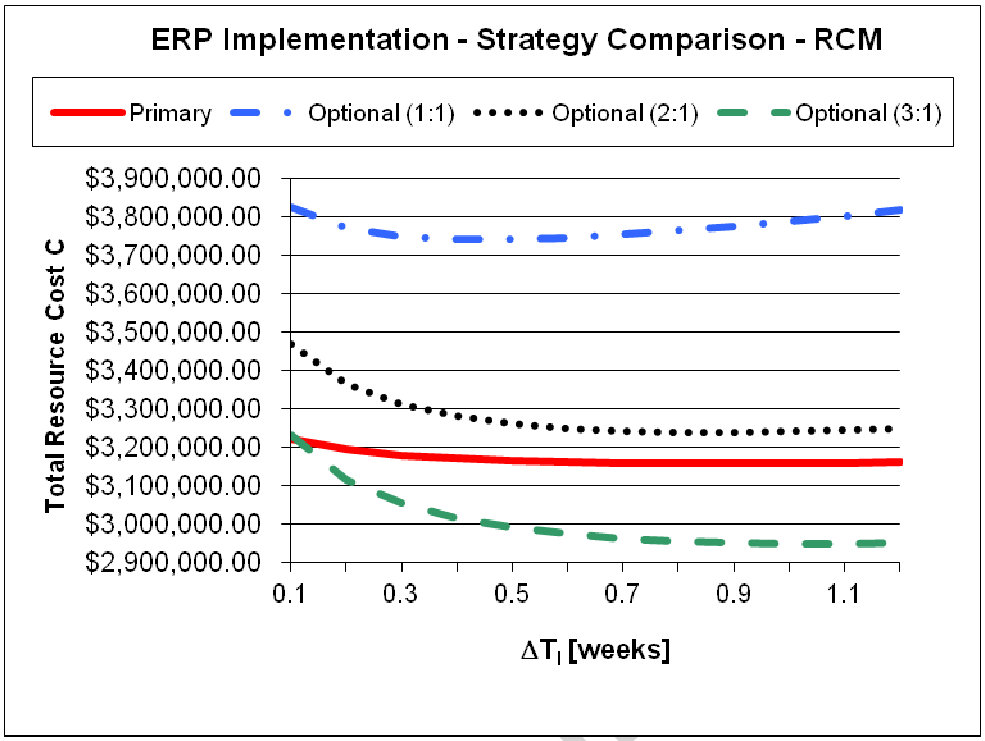


Figure 3a. Analysis of the total resource cost for Project A1. Cost of internal resources R_S=\$500/day.

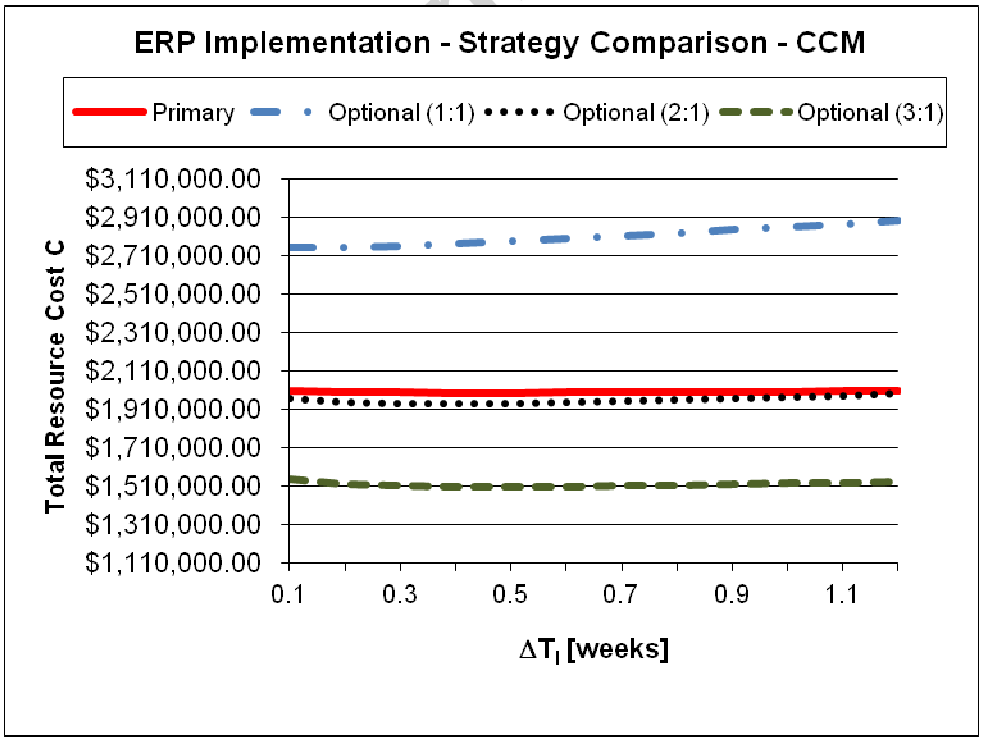


Figure 3b. Analysis of the total resource cost for Project A1. Cost of internal resources R_S=\$0/day.

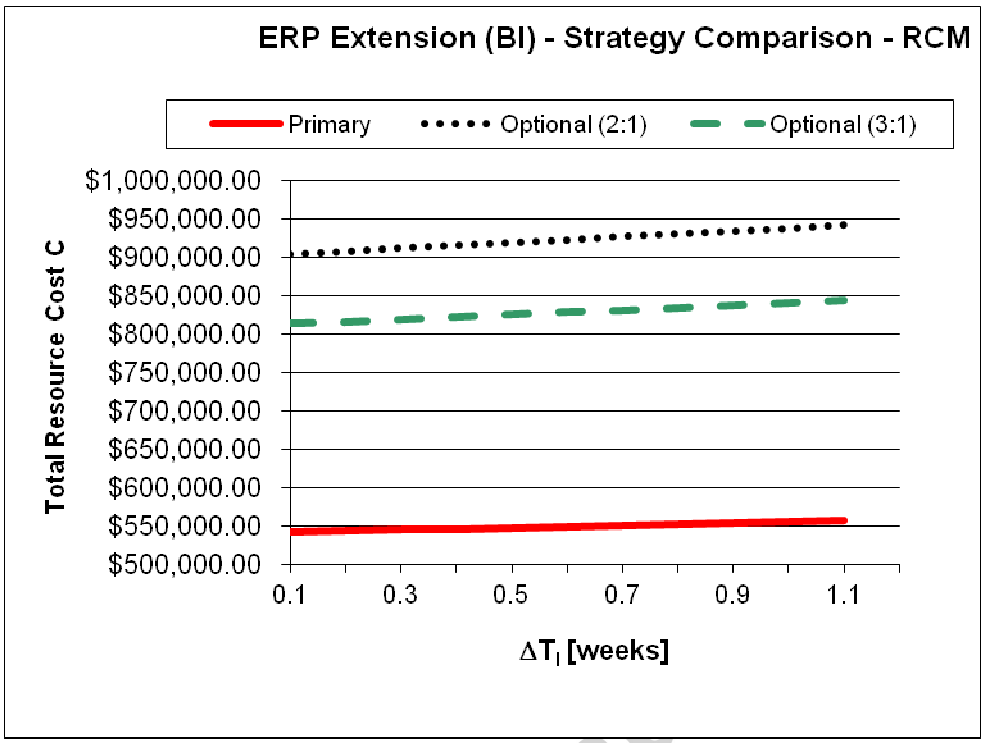
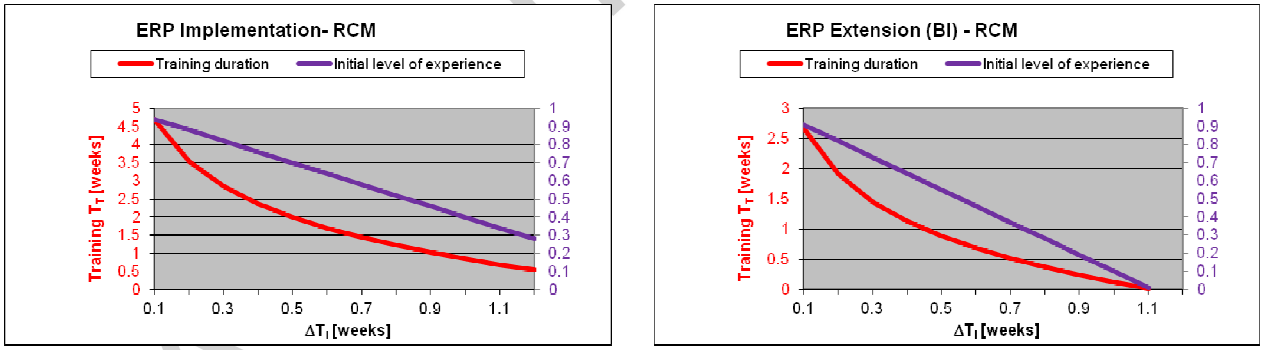


Figure 3c. Analysis of the Total Resource Cost for Project B2. Cost of internal resources R_S=$500/day.



4a 4b

Figure 4. Training duration and initial level of experience required for Project A1- Figure 4a and Project B2 – Figure 4b

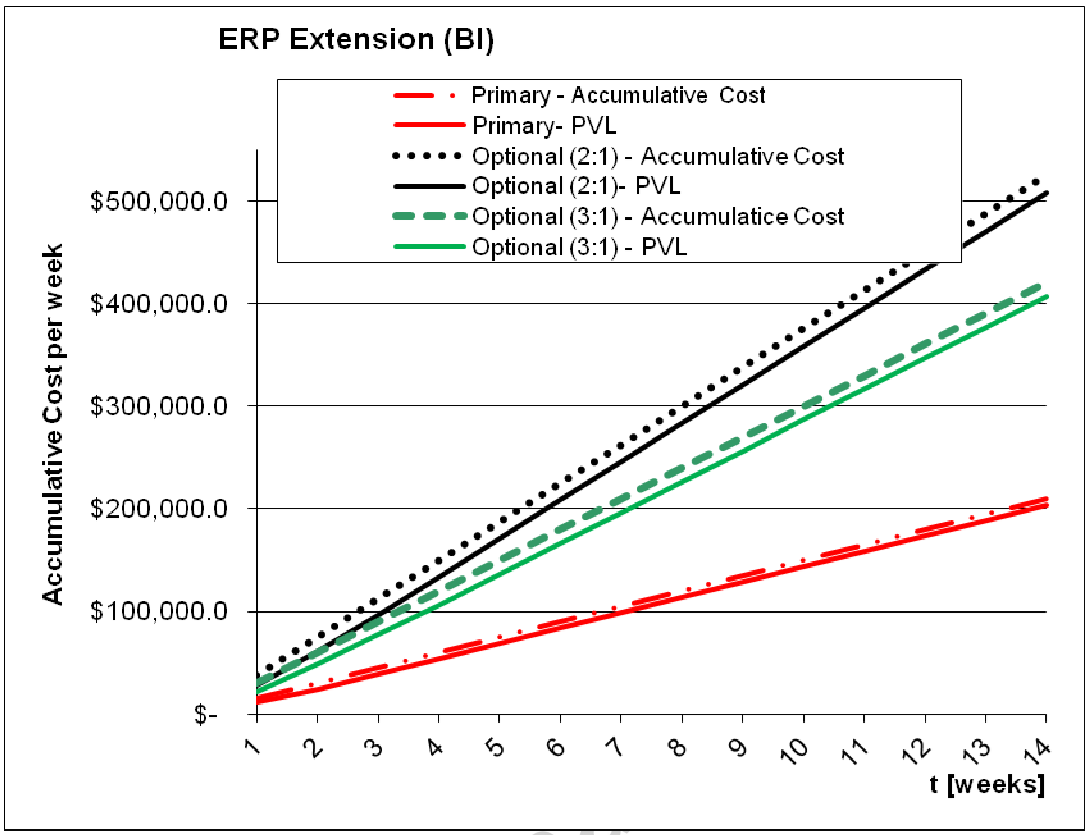


Figure 5. Cash Outflows (Cost Formula) and Output Delivered (Baseline Equation) for Project B2.

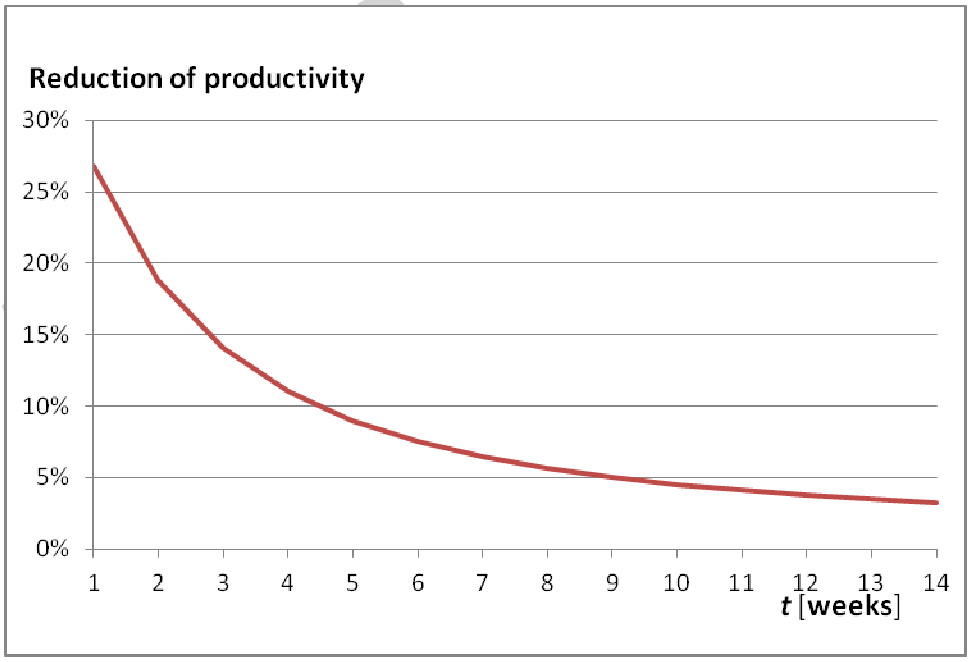


Figure 6. Reduction of project outputs as a function of time elapsed on Project B2.

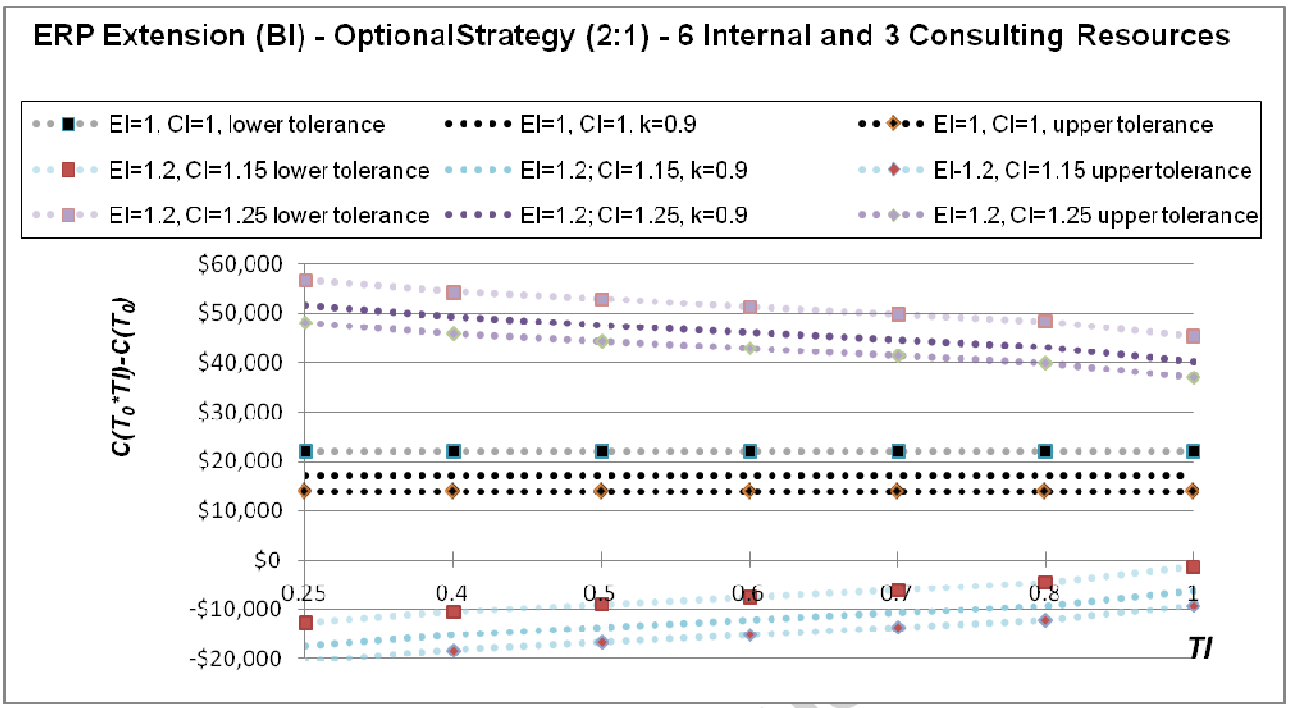


Figure 7. Cost Adjustment as a function of duration compression ratio for Project B2 - Optional Strategy 2:1 Internal to External Resource Ratio, 60% of Initial Performance.

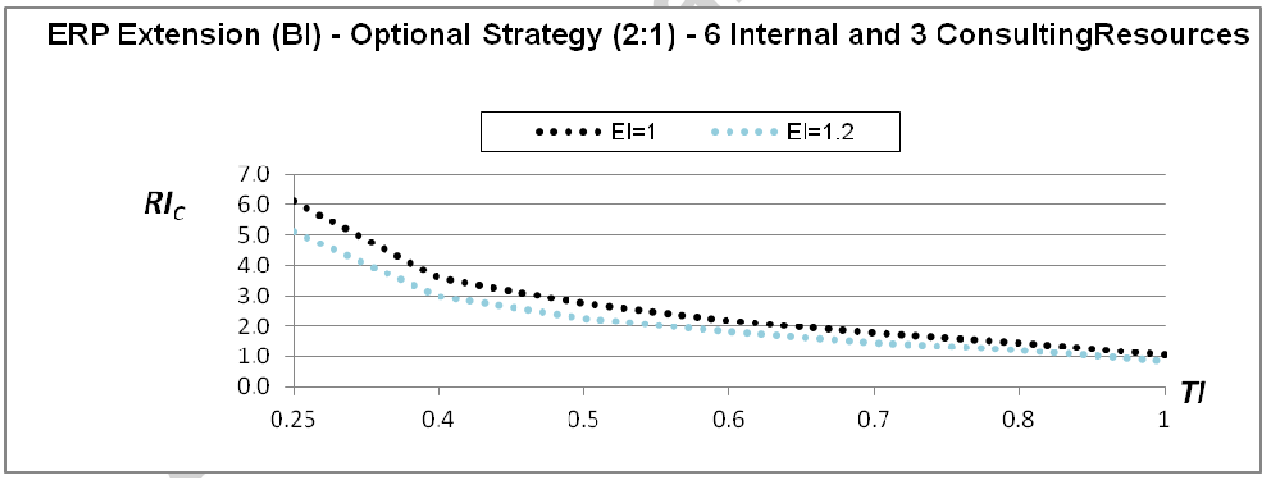


Figure 8. Consulting Resource Index as a function of duration compression ratio for Project B2 - Optional Strategy 2:1 Internal to External Resource Ratio, 60% of Initial Performance.

Table 1. Projects data and results.

	Project A1 – ERP Implementation				Project B2 – ERP Extension (BI)		
(Strategy) Resource Ratio	**(Primary) 2:1**	Optional 1:1	Optional 2:1	Optional 3:1	**(Primary) 1:0**	Optional 2:1	Optional 3:1
PROJECT DETAILS							
k [1/week]	**0.6**	0.7	0.6	0.6	0.9		
P_0 [%]	0				60%		
N_S (R_S: \$500/day)	**8**	24	32	36	**6**	6	6
N_I (R_I: \$1900/day)	**1**	2	3	3	-		
N_C (R_C: \$1500/day)	**4**	24	16	12	-	3	2
N_{CM} (R_{CM}: \$2000/day)	**0.5**	1	1	1	-		
T_0 [week]	**56**	14			**36**	24	27
RESULTS SUMMARY (RCM) (Figures 3a, 3c, 4a and 4b)							
$C(\Delta T_{Iopt})$ [\$]	3,159,795	3,743,476	3,240,403	2,951,000	N/A		
ΔT_{Iopt} [week]	0.9	0.5	0.9	1			
T_{Topt} [week]	1	2	1	0.9			
$T_T(P_0)$ [week]	N/A				1		
$\Delta T_I(P_0)$ [week]					0.45		
$C(\Delta T_I(P_0))$ [\$]					547,000	918,000	823,000
RESULTS SUMMARY (CCM) (Figures 3b and 4a)					**-**		
$C(\Delta T_{Iopt})$ [\$]	1,996,481	2,764,575	1,939,579	1,507,117	N/A		
ΔT_{Iopt} [week]	0.45	0.17	0.37	0.48			
T_{Topt} [week]	2.17	3.84	2.53	2.09			
**Living and travel expenses are not included, since the resources were local*							