# Benchmarking Data as a basis for Choosing a Business Software Systems Development and Enhancement Project Variant – Case Study

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***Abstract*—Execution of Business Software Systems (BSS) Development and Enhancement Projects (D&EP) is characterised by the exceptionally low effectiveness, leading to the considerable financial losses. Thus, it is necessary to rationalize investment decisions made with regard to the projects of this type. Each rational investment decision should meet two measurable criteria: effectiveness and economic efficiency. In order to make *ex ante* evaluation of these criteria, being key to the decision-making process, one may successfully use ever richer resources of benchmarking data, having been collected in special repositories that were created with improvement of software processes and products in mind. The goal of this paper is to present possibilities of employing benchmarking data in the rationalization of investment decision concerning the choice of BSS D&EP execution variant on the basis of a case study. Thanks to the rational investment decisions made on the basis of reliable and objective benchmarking data it is possible to reduce losses caused by the low effectiveness of BSS D&EP. These issues classify into economics problems of software engineering.**

***Keywords-software engineering economics; business software systems development and enhancement projects variants; rational investment decision; effectiveness; efficiency; benchmarking data; case study***

## I. INTRODUCTION

In practice, execution of Business Software Systems (BSS) Development and Enhancement Projects (D&EP) is characterised by the exceptionally low effectiveness, leading to the considerable financial losses (the paper is an extended version of [1]). This may be proved by numerous analyses. As indicated by the results of the Standish Group studies success rate for application software D&EP has never gone beyond 37% [2], while products delivered as a result of nearly 45% of them lack on average 32% of the required functions and features, the estimated project budget is exceeded by approx. 55% on average and the planned project time – by nearly 80% on average [3] (for more details see [4]). Analyses by T.C. Jones plainly indicate that those software D&EP, which are aimed at delivery of business software systems, have the lowest chance to succeed [5]. The Panorama Consulting Group, when investigating in their 2008 study the effectiveness of ERP (Enterprise Resource Planning) systems projects being accomplished worldwide revealed that 93% of them were completed after the scheduled time while as many as 68% among them were considerably delayed comparing to the expected completion time [6]. Merely 7% of the surveyed ERP projects were accomplished as planned. Comparison of actual versus planned expenses has revealed that as many as 65% of such projects overran the planned budget. Only 13% of the respondents expressed high satisfaction with the functionality implemented in final product while in merely every fifth company at least 50% of the expected benefits from its implementation were said to be achieved. Three years later, the respondents of Panorama Consulting Group study indicated that there were significantly more companies with ERP project overruns in 2010 than in 2009 [7].

Similar data, proving unsatisfactory effectiveness of BSS D&EP, are brought by the studies carried out in 2011 among providers of such projects in Poland [8]. According to the results, 80% of the surveyed organizations admit that the projects exceed the planned budget, 79% - that they exceed the planned execution time while 64% - that the quality assumptions for software products are not being met. In this case it results from the fact that slight percentage of providers manages the software systems development processes properly. What is interesting, all those numbers increase if the so-called expert methods are used to estimate project attributes – instead of estimates being based on standards and benchmarking data (most preferably own ones).

Meanwhile BSS are not only one of the fundamental IT application areas; also their development/enhancement often constitutes serious investment undertaking: spending on BSS may considerably exceed the expense of building even 50-storey skyscraper, roofed football stadium, or cruising ship with a displacement of 70.000 tons [9]. Yet quite often client spends these sums without supporting his decision on getting engaged in such investment by proper analysis of the costs, based on the rational, sufficiently objective and reliable basis. What is more, in practice COTS (Commercial-Off-The-Shelf) BSS rarely happen to be fully tailored to the particular client business requirements therefore their customization appears vital (see also [4]).

Exceptionally low effectiveness of BSS D&EP as compared to other types of IT projects (i.e., maintenance, support, package acquisition, implementation projects, projects delivering other types of software), especially with their costs being considered, leads to the substantial financial losses, on a worldwide scale estimated to be hundreds of billions of dollars yearly, sometimes making even more than half the funds being invested in such projects. The Standish Group estimates that these losses – excluding losses caused by business opportunities lost by clients, providers losing credibility or legal repercussions – range, depending on the year considered, from approx. 20% to even 55% of the costs assigned for the execution of the analysed projects types (see e.g., [10], [11]). If direct losses caused by abandoning the BSS D&EP result from erroneous allocation of financial means, usually being not retrievable, in the case of overrunning the estimated cost and/or time, however, they may result from delay in gaining the planned return on investment as well as from decreasing it (necessity to invest additional funds and/or cutting on profits due to the overrunning of execution time and/or delivery of product incompatible with requirements) (for more details see [12]). On the other hand, analyses of The Economist Intelligence Unit, which studied the consequences of BSS D&EP delay indicate that there is strong correlation between delays in delivery of software products and services and decrease in profitability of a company therefore failures of BSS D&EP, resulting in delays in making new product and services available and in decreasing the expected income, represent threat also to the company's business activity [13].

What is more, the Standish Group studies also indicate that "the costs of these (...) overruns are just the tip of the proverbial iceberg. The lost opportunity costs are not measurable, but could easily be in the trillions of dollars. [For instance - B.C.C.] the failure to produce reliable software to handle baggage at the new Denver airport is costing the city $1.1 million per day" [14]. These losses result from the insufficient level of the delivered product compatibility with the client's requirements as to the functions and features: over 1994-2010 an average conformity of this type never went beyond 70%, which means that the delivered applications lacked at least 30% of the specified functions and features [3]. Incompatibility of the delivered product with the required one proves to be the highest for large projects, in case of which the delivered product lacks on average even 60% of the required functions and features. While for medium- and small-sized projects such incompatibility amounts to approx. 35% and approx. 25% of functions and features, respectively.

The above studies unequivocally indicate there is a significant need to rationalize investment decisions made with regard to BSS D&EP. To do so, one may successfully use ever richer resources of benchmarking data, having been collected with the intention to support improvement of various IT projects, including BSS D&EP, in special repositories (for more details see [15]). The goal of this paper is to present possibilities of BSS D&EP investment decision rationalization with the use of benchmarking data, illustrated with an example taken from development practice. This decision concerns choosing variant of BSS D&EP execution – since each project of this type may be executed using one of the three variants, namely: (1) developing new BSS from scratch, (2) customization of COTS BSS, and (3) modernization of BSS being currently used.

The paper is structured as follows: in Section 2 the author presents the criteria of rational investment decision in the context of BSS D&EP along with the selected results of studies concerning *ex ante* evaluation of these criteria. Section 3 is devoted to the presentation of the considered case study problem. In Section 4 the main conclusions coming from the benchmarking data analysis are pointed out, while in Section 5 the effectiveness and efficiency factors for the recommended BSS D&EP variant are analyzed. Finally, in Section 6 the author draws conclusions and some open lines about future work on the usefulness of benchmarking data, not only in the context of rationalization of BSS D&EP investment decision.

## II. Rational Investment Decision Criteria for Business Software Systems Development and Enhancement Projects

Each rational investment decision should meet three criteria, which in the context of BSS D&EP should be interpreted as follows:

- Criterion of consistency, which means that the project undertaken should comply with the environment (economic, organizational, legal and cultural) – unlike the other two criteria, this criterion is not subject to quantitative assessment therefore it is skipped in this paper.
- Criterion of economic efficiency, meaning that the decision should benefit to the maximisation of the relationship between the effects to be gained as a result of project execution and the costs being estimated for the project.
- Criterion of effectiveness, meaning that such decision should contribute to achieving the assumed result, in the case of BSS D&EP usually being considered as delivering product meeting client's requirements with regard to functions and features without budget and time overruns.

Generally speaking, in the case of economic efficiency evaluation, effects are compared against costs necessary to achieve these effects while in the case of effectiveness evaluation these are only the results that are of significance. Thus, economic efficiency is measured by relating total effects to total costs. Meanwhile, effectiveness is measured by the ratio of the achieved result to the assumed result, which is being conveniently expressed as a percentage.

Both economic efficiency criterion as well as effectiveness criterion are based on the obvious assumption that the effects, costs and results are measurable. However, in the case of BSS D&EP this assumption is often treated as controversial. Numerous studies indicate that evaluation of BSS D&EP economic efficiency is made relatively rarely while fundamental reason for this *status quo* are difficulties related to identification, and most of all quantitative expression, of benefits resulting from the execution of such projects (see e.g., [16], [17], [18], [19], [20]). These studies reveal that difficulties related to identification and quantitative expression of BSS D&EP costs too are of significance, which also is of importance to the evaluation of their effectiveness.

Key conclusions coming from the above mentioned studies have also been confirmed by the results of studies carried out by the author of this paper in two research cycles among Polish dedicated BSS providers (for more details see [21]). They revealed that at the turn of the years 2005/2006 the results obtained with the use of the effort estimation methods, employed only by approx. 45% of the respondents, were designed for estimating BSS D&EP costs and time frame while relatively rarely they were used to estimate economic efficiency – such use of these methods was indicated by only 25% of those using effort estimation methods. Heads of IT departments in Polish companies, for which BSS D&EP are executed, still explain the sporadically required calculation of this type of investments efficiency mostly by the necessity to undertake them – most often due to the fact that without such solutions they lack possibility to match competition from foreign companies, as well as to match foreign business partners requirements. While Polish public administration institutions in practice still do not see the need for the BSS D&EP economic efficiency evaluation, in most cases as an argument giving the non-economic purposes of systems being implemented in this type of organizations. On the other hand, at the turn of the years 2008/2009 the results obtained with the use of the BSS D&EP effort estimation methods (approx. 53% of BSS providers surveyed in this cycle declared they commonly employed such methods) were more often used to estimate efficiency: there was an increase to approx. 36% of those using effort estimation methods. This applies to internal IT departments of Polish companies yet still it does not comprise public administration institutions. This increase may be explained first of all by stronger care about financial means in the times of recession, however it still leaves a lot to be desired. Meanwhile, to rationalize various BSS D&EP investment decisions, one may successfully use benchmarking data, having been collected in special repositories with intention to support effective and efficient execution of such projects.

## III. CASE STUDY: DESCRIPTION OF THE PROBLEM

A company that was facing the need to choose an appropriate variant of BSS D&EP execution collects and processes, as a part of its basic activity, orders for certain goods from all over the world in a 24-hour mode, 7 days a week through: website, client service centres, fax and electronic mail (description of the case study taken from [22]). All those channels cooperate with the application, having been functioning in the company for a dozen or so years already, designed for orders processing and which is no longer able to satisfy present requirements since:

- Large part of processes is not automated, which requires additional work for registering orders and that generates losses.
- Current status of orders is not known therefore they are being lost; as a result of this other losses are also borne, which together with earlier mentioned losses are estimated to be approx. USD 5000 a day.
- System is expensive and difficult to maintain, with frequent malfunctions as it employs obsolete technology.
- System extends the time of delivering new products to the market, increases the risk of losing clients and lack of compliance with their requirements, slows down the growth of competitive advantage.

Thus, the company has faced a decision on choosing variant of BSS D&EP execution that would:

- Eliminate the above mentioned drawbacks of the existing solution.
- Contribute to short- and long-term profits – that's why the costs and duration of project are of great significance.
- Reduce the costs of functioning of both company and technology.
- Contribute to the reduction of risk, both in terms of business and technology.

TABLE I. PARAMETERS OF OFFERS CONCERNING EXECUTION OF PARTICULAR VARIANTS OF BSS D&EP CONSIDERED

| Variant | BSS D&EP variant | Execution cost offered | Execution time offered |
|---|---|---|---|
| 1 | Development of new BSS from scratch using modern technologies | USD 10 million | 3 years |
| 2 | Customization of BSS purchased | USD 5 million | 2 years |
| 3 | Modernization of BSS used currently | USD 3,5 million | 1,5 years |

Source: Author's analysis based on [22, p. 2].

Offers for each BSS D&EP variant were submitted, having approximate average values as shown in Table I.

Since each variant was backed by certain part of the board and key users, an analysis aimed at supporting decision-making process was carried out.

## IV. CONCLUSIONS FROM THE BENCHMARKING DATA ANALYSIS

The analysis used benchmarking data for BSS D&EP having been collected in the following repositories:

- Standish Group, featuring data about over 70 thousands of the accomplished application software D&EP, which were analysed using the tool called *VirtualADVISOR* [22].
- Software Productivity Research (SPR), containing data from approx. 15 thousands of the accomplished application software D&EP, which were used to verify conclusions coming from Standish Group repository analysis with the use of *SPR Knowledge Plan* tool [23].

- International Software Benchmarking Standards Group (ISBSG), having collected data from approx. 5 thousands of the accomplished application software D&EP [24], also used to verify findings coming from Standish Group repository analysis and also with the use of *SPR Knowledge Plan* tool, which at its present version offers possibility to import data from the ISBSG repository.

Priority was given to the Standish Group data and this being not only due to the size of this repository, objectivity of data (they come solely from clients) or the fact of IT branch appreciating its practical value [10] but also because they take into account an appropriate kind of client (in terms of branch and size of a company), appropriate kinds and size of BSS D&EP as well as appropriate type and size of application. Thus, using the Standish Group repository made it possible to match all three kinds of BSS D&EP against the profile, with 90% match of the 120 attributes of more than 100 projects [22].

What is also important, in their analyses the Standish Group employ clearly defined criteria of project classification, dividing projects into the following three groups (see e.g., [3], [11], [25]):

- Successful projects – that is projects completed with delivery of product having functions and features being in accordance with client requirements specification and within the estimated time and budget.
- Challenged projects – that is projects completed with delivery of product that is operating yet has fewer vital functions/features comparing to the client requirements specification and/or with overrun of the planned budget and/or duration.
- Failed projects – that is projects that were abandoned (cancelled) at some point of their life cycle or were completed with delivery of product that had never been used.

The Standish Group conducts its researches mostly from the point of view of the so-called success coefficient, which describes the share of successful projects in the total number of analysed projects completed during given year. What represents counterbalance to the projects comprised by the success coefficient are projects that ended with total or partial failure, i.e., failed and challenged projects. In case of challenged projects, this is also degree of fitness of the delivered product to the functions and features required by a client. Since the mid-1990s these numbers have shaped as shown in Table II.

In the analysis of the Standish Group data, the following criteria were employed as equivalent for particular variants of the BSS D&EP considered:

*1)* Criterion of expected BSS D&EP effectiveness, including:

*a)* chance to succeed

*b)* level of planned costs overrun

*c)* level of planned duration overrun.

*2)* Criterion of expected BSS D&EP efficiency, including:

*a)* return on investment (ROI)

*b)* payback period.

TABLE II. AVARAGE EFFECTIVENESS OF APPLICATION SOFTWARE D&EP EXECUTION OVER 1994-2010

| Data for | Success coefficient (in %) | Partial failure (in %) | Total failure (in %) | Partial and total failure (in %) |
|---|---|---|---|---|
| 1994 | 16 | 53 | 31 | 84 |
| 1996 | 27 | 33 | 40 | 73 |
| 1998 | 26 | 46 | 28 | 74 |
| 2000 | 28 | 49 | 23 | 72 |
| 2002 | 34 | 51 | 15 | 66 |
| 2004 | 29 | 53 | 18 | 71 |
| 2006 | 35 | 46 | 19 | 65 |
| 2008 | 32 | 44 | 24 | 68 |
| 2010 | 37 | 42 | 21 | 63 |

Source: [2] and [3].

Data presented in Table III clearly indicate that in the case being considered the highest chance to succeed is held by modernization variant, for which success coefficient is several times higher than that characteristic of variant consisting in development of new application, being only 4% (sic!), and significantly higher than that of COTS customization variant. Also in case of variant 3 the lowest percentage of projects ends with being abandoned – it is several times lower than in case of variant 1 and two times lower than in case of variant 2. What seems interesting, the highest percentage of projects that ended in partial failure (challenged projects) occurs in case of the customization of COTS application. What is more, the average expected overrun of both costs (see Table IV) and project duration (see Table V) is also the highest in case of this project variant.

TABLE III. EXPECTED CHANCE TO SUCCEED FOR PARTICULAR VARIANTS OF BSS D&EP CONSIDERED

| Resolution | Variant 1 | Variant 2 | Variant 3 |
|---|---|---|---|
| Successful | 4% | 30% | 53% |
| Challenged | 47% | 54% | 39% |
| Failed | 49% | 16% | 8% |

Source: [22, p. 4].

Moreover, data in Table IV clearly indicate that the average expected overrun of the planned costs for projects that ended in partial failure too is the lowest in case of variant 3. Also the lowest percentage of such projects overruns the costs by more than 50%. If offered costs and average expected overrun of these costs are taken into consideration when calculating the expected cost then it appears evident that the lowest expected cost of project execution applies to modernization variant.

TABLE IV. EXPECTED LEVEL OF PLANNED COST OVERRUN FOR PARTICULAR VARIANTS OF BSS D&EP CONSIDERED (CHALLENGED PROJECTS)

| Cost overrun | Variant 1 | Variant 2 | Variant 3 |
|---|---|---|---|
| 0% to 50% | 64% | 58% | 75% |
| 51% to 50% | 36% | 42% | 25% |
| Average | 44% | 47% | 34% |
| Offered cost | USD 10 million | USD 5 million | USD 3,5 million |
| Estimated cost | USD 14,4 million | USD 7,35 million | USD 4,7 million |

Source: Author's analysis based on [22, p. 4].

Analogous conclusions may be drawn on the basis of the analysis of data presented in Table V. Again, the average expected overrun of the planned duration for projects that ended in partial failure proves being the lowest for variant 3. Also the lowest percentage of such projects overruns the duration by more than 50%. If we take into account the offered duration and average expected overrun of this duration then we can see that the lowest expected duration of project execution applies to modernization variant too.

TABLE V. EXPECTED LEVEL OF PLANNED DURATION OVERRUN FOR PARTICULAR VARIANTS OF BSS D&EP CONSIDERED (CHALLENGED PROJECTS)

| Duration overrun | Variant 1 | Variant 2 | Variant 3 |
|---|---|---|---|
| 0% to 50% | 57% | 59% | 80% |
| 51% to 50% | 43% | 41% | 20% |
| Average | 44% | 45% | 29% |
| Offered duration | 36 months | 24 months | 18 months |
| Estimated duration | 52 months | 35 months | 23,5 months |

Source: Author's analysis based on [22, p. 4].

Data shown in Table VI clearly indicate that the highest percentage of projects characterised by the highest ROI can be found in case of variant 3 again. On the other hand, what is interesting is that projects with average ROI most often are projects consisting in developing new application from scratch while the lowest percentage of projects characterised by the lowest ROI can be found in case of customization variant.

TABLE VI. EXPECTED ROI FOR PARTICULAR VARIANTS OF BSS D&EP CONSIDERED

| ROI | Variant 1 | Variant 2 | Variant 3 |
|---|---|---|---|
| High | 11% | 34% | 52% |
| Average | 66% | 57% | 37% |
| Low | 23% | 9% | 11% |

Source: [22, p. 5].

In Table VII both ROI and payback period for particular variants of the considered project were estimated in optimistic and pessimistic version. In the optimistic version it was assumed that the costs were identical with the offered costs while in the pessimistic version - that the costs were exceeded by the average values being expected for each variant analysed (see Table IV). Based on these assumptions, both in optimistic and in pessimistic version, the highest 5-year gain applies to the modernization variant; also in case of that variant the payback period proves the shortest. It is worth noting that project in variant consisting in developing the new application would pay off after nearly 5 and half years in the optimistic version and after nearly 7 and half years in the pessimistic version.

TABLE VII. EXPECTED ROI AND PAYBACK PERIOD FOR PARTICULAR VARIANTS OF BSS D&EP CONSIDERED

| | Optimistic version | | | Pessimistic version | | |
|---|---|---|---|---|---|---|
| Variant | Costs (in $ millions) | 5-year gain (in $ millions) | Payback period (in years) | Costs (in $ millions) | 5-year gain (in $ millions) | Payback period (in years) |
| 1 | 10 | 0 | 5,4 | 14,4 | 0 | 7,3 |
| 2 | 5 | 7,25 | 3,2 | 7,35 | 2,8 | 4,4 |
| 3 | **3,5** | **10,6** | **2,4** | **4,69** | **7,9** | **3,1** |

Source: Author's analysis based on [22, p. 5].

The above analysis clearly indicates that what in the considered case would be the best of the three BSS D&EP variants both from the perspective of the expected effectiveness and from the perspective of the expected efficiency is variant consisting in modernization of the application being used (variant 3).

## V. THE EFFECTIVENESS AND EFFICIENCY FACTORS FOR THE RECOMMENDED VARIANT

In the analysed case, BSS D&EP consisting in modernization of application being used proves the most effective as well as the most efficient, what results, among others, from (see also [22]):

- Undertaking of such projects as a rule is a result of clearly defined needs of users therefore their goals are comprehensible, what undoubtedly promotes users' engagement in the project and the board's support for the project, which, according to the list of success factors having been developed by the Standish Group since 1995, are still the two most important success factors [25].
- The fact that modernization projects do not require extensive analysis of requirements, numerous agreements, long-time training, changes of processes that would be destabilizing the work.
- Commonness of such projects thus, the skills of executing them are high; what is more, projects of this type do not require additional skills in terms of project management, they rather require technical, the so called „hard", skills.
- Present structure of project costs in terms of development activities, which due to the increased complexity of projects and ever more developed tools has changed and is now in inverse proportion

to the structure as it was 25 years ago: now programming costs make up approx. 20% while other development works make up approx. 80% of the total cost.

- The fact that modernization projects are characterised by the lowest hidden cost (mainly user's time), estimated to be 15% of project costs versus 55% for variant 2 and versus 35% for variant 1.
- The discussed projects do not have redundant requirements – as this is the case of the COTS customization where, according to the Standish Group data, less than 5% (sic!) of the features and functions get used [22], and of the development of new products (see Figure 1).

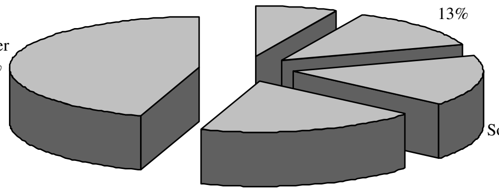


Figure 1. Average use of functions and features in the implemented software systems - custom development applications

Source: Author's analysis based on [22, p. 15].

- Products smaller than those in case of developing application from scratch are developed as a result of the modernization projects and this is what increases their chance to succeed. Smaller products are usually delivered as a result of smaller projects.
- The discussed projects may be successfully carried out using agile approach, which also ranks high in the current list of Standish Group success factors [25]. The main objective of agile models is to quickly develop software that would be working correctly and this being thanks to focusing on strictly construction activities and keeping other activities down to a minimum, and not methodologically correct execution of that process instead [26]. Agile models were mostly developed for small and medium projects and they are used in rather small teams wherein there is no communication problem. They also require diverse and extensive knowledge and experience of the team members, and stable teams, located and working in one place throughout the project. Permanent accessibility of client's representatives is also necessary. The Software Productivity Research study found that in the area of construction models usage there are some trends associated with industries and forms of software, e.g., business software systems and web applications are more likely to use agile models than are systems software projects and military projects [27, pp. 6-7].

As far as the two last mentioned factors are concerned, it should be stressed that according to the analyses of Standish Group [11, p. 4], Software Productivity Research [28], and ISBSG [29, p. 2] this is minimisation of project size, first of all caused by the agile models having been used more and more often over time, that is responsible for the improvement of the application software D&EP effectiveness over 1994-2010: during that time the success coefficient has increased from 16% to 37% as both partial and total failure have decreased (see Table II). Failure to deliver functions and features required by a client also decreased (from 40% to 32%), as did the planned time overrun (from 164% to 79% - more than doubly) as well as planned budget overrun (from 180% to 55% - over three times) ([2], [14]). Thus, the losses resulting from the low scale of application D&EP effectiveness have shrunk considerably: from approx. USD 140 million to approx. USD 55 million, which accounts for the decrease of loss level from approx. 55% of the means invested in considered projects to approx. 20-25% of such means. Conclusion on the positive influence of the project sizes minimisation on their effectiveness gets confirmed by the data shown in Tables VIII and IX.

TABLE VIII. THE EFFECTIVENESS OF APPLICATION SOFTWARE D&EP EXECUTION BY PROJECT SIZE

| Project size – measured by the work cost (in USD millions) | Success coefficient (in %) | Partial failure (in %) | Total failure (in %) |
|---|---|---|---|
| Over 10 | 0 | 11 | 19 |
| 6 – 10 | 6 | 20 | 28 |
| 3 – 6 | 13 | 36 | 39 |
| 0,75 – 3 | 19 | 18 | 8 |
| Under 0,75 | 62 | 15 | 5 |
| Total | 100 | 100 | 100 |

Source: [25, p. 21].

As it may be seen in Table VIII, over 80% of the successful projects demonstrate having work cost up to USD 3 million whereas the work cost in nearly 20% of such projects ranges from USD 3 to 10 million. On the other hand, data in Table IX indicate that for application D&EP costing below USD 750 000, the chance to succeed is as high as 71% while for projects having work cost over USD 10 million it is barely 2%.

Meanwhile, comparison of the effectiveness of projects execution using agile models versus that using waterfall model (see Table X) leads to the conclusion that in case of agile projects the success coefficient is significantly higher yet still far from being regarded as satisfactory – even if we take into account that in this case it is above the average success coefficient. Partial failure too is lower in case of agile approach, however it almost equals its average value. Also, what definitely is worth pointing out is the fact that total failure both in case of agile and waterfall model is significantly lower than the average: for agile models – twice. In case of waterfall model smaller scale of total failure does not have influence on increasing success coefficient but it does on increasing partial failure instead (such kind of failure, however, generates smaller losses than total failure does).

TABLE IX. THE APPLICATION SOFTWARE D&EP SIZE BY THE PROJECT EXECUTION EFFECTIVENESS

| Project size – measured by the work cost (in USD millions) | Success coefficient (in %) | Partial failure (in %) | Total failure (in %) | Total |
|---|---|---|---|---|
| Over 10 | 2 | 50 | 48 | 100 |
| 6 – 10 | 11 | 51 | 38 | 100 |
| 3 – 6 | 14 | 54 | 32 | 100 |
| 0,75 – 3 | 38 | 49 | 13 | 100 |
| Under 0,75 | 71 | 24 | 5 | 100 |

Source: [25, p. 30].

TABLE X. THE EFFECTIVENESS OF APPLICATION SOFTWARE D&EP EXECUTION – WATERFALL VS. AGILE MODEL

| Effectiveness | Waterfall model | Agile model | Average in 2010 |
|---|---|---|---|
| Success coefficient (in %) | 26 | 43 | 37 |
| Partial failure (in %) | 59 | 45 | 42 |
| Total failure (in %) | 15 | 12 | 21 |

Source: [2], [25, p. 21].

However, modernization variant recommended in the discussed case is not devoid of drawbacks though. Most of all, it evidently is not suitable for organizations where BSS had not functioned so far (in Poland approx. 95% of small companies do not use BSS – comparing to 50% in developed countries), for new organizations, new departments, and in case of fusion the modernization often ends in failure too. Moreover in modernization variant there are limited possibilities to implement fundamental business changes. What is more, the use of obsolete technologies is being continued, what makes cooperation with modern applications difficult, reduces usability, portability and maintainability of the modified application; performance is usually lower too. It is worth stressing that these attributes are the software product quality attributes of the ISO/IEC 9126 norm [30]. Thus, what appears to be open to doubt is reduction of costs and difficulties in maintaining the system as well as technological risk - this being one of the major goals of the solution variant to be chosen (see Section 2). It is also worth mentioning that the ISBSG data indicate lower productivity of such projects: in case of BSS D&EP consisting in developing new BSS from scratch it ranges on average from 9 (for 4GL) to 24.5 (for 3GL) work hours for developing 1 function point whereas in case of modernization projects it takes approx. 27 work hours on average to develop 1 function point [31].

## VI. CONCLUSION AND FUTURE WORK

Based on the analysis of benchmarking data coming from the Standish Group repository, having been carried out with the use of *VirtualADVISOR* tool, it was concluded that what proves the best among the three BSS D&EP variants *in the discussed case* is variant consisting in modernization of application being used. Data analysis indicates that choosing the above mentioned variant is rational due to the criterion of both expected effectiveness and expected efficiency of project. This conclusion has been confirmed by the verification based on the repository of the SPR and ISBSG data, having been carried out with the use of *SPR Knowledge Plan* tool.

From the point of view of effectiveness and efficiency, modernization variant has many advantages yet it is not devoid of drawbacks though. What is more, this does not have to be the best solution in other cases, e.g., for real time systems, for small software product development/ enhancement projects, or for organizations that specialise in developing specific kind of new software systems where there is possibility to use the already written code. It should be also mentioned that projects of higher risk, i.e., those having lower chance to succeed, often happen to be more efficient.

As indicated by the study results discussed in this paper, in view of exceptionally low effectiveness of BSS D&EP it is necessary to rationalize investment decisions being made with regard to such projects. To do so one may successfully use ever richer resources of benchmarking data having been collected in repositories with intention to support effective and efficient BSS D&EP execution. In the opinion of T.C. Jones: "For many years the lack of readily available benchmark data blinded software developers and managers to the real economics of software. Now (…) it is becoming possible to make solid business decisions about software development practices and their results (…). [Benchmarking – B.C.C.] data is a valuable asset for the software industry and for all companies that produce software" [32].

Appropriate benchmarking data most of all mean data pertaining to the type of software projects considered, being representative of this type. Undoubtedly the best solution is a situation when organizations use their own benchmarking data yet in practice it still happens that they rarely collect such data in a reliable and systematic manner, necessary to derive dependencies being specific to them. What reveals in this case is usefulness of repositories collecting general benchmarking data, created with improvement of software processes and products in mind. Repositories collecting general benchmarking data about software systems D&EP completed in the past include, apart from the information on mean values, also more precise data, dependent, among others, on the specificity of project and its product. Such repositories, which should be standardised according to the ISO/IEC 15939 norm [33], recent and representative of current technologies, may also support, among others (for more details see [15] and [34, pp. 3-4]):

- Proper software systems D&EP planning through:

- verification of the product requirements completeness,
- early and reliable estimation of the product size as well as project effort, cost and time,
- determining product size in a way so that it would ensure possibility of completing project on time and within the planned budget,
- determining optimum size of project team,
- finding balance among project attributes yet with priorities being taken into account (e.g., quality versus productivity),
- considering the outsourcing option,
- defining components of project environment,
- determining the influence of the chosen development tools and methods on the project,
- pricing of the product based on the cost per functional unit (i.e., function point - for more details see [12]).

- Proper management of the project risk through the verification of estimates for the project attributes reliability.
- Early and reliable control of project attributes throughout its accomplishment.
- Evolution of software D&EP organizations through possibility of:
  - comparing characteristics typical of given organization with characteristics in organizations having similar business profile (e.g., insurance, manufacturing, banking),
  - building organizational own database on project productivity,
  - increasing productivity of project activities,
  - reducing "time to market", that is reducing time of developing and launching new products to the market.

On the other hand, this paper presented the possibility of using benchmarking data by a client in the rationalization of investment decision concerning the choice of the BSS D&EP execution variant, illustrated on the basis of a case study. Thanks to the rational investment decisions made on the basis of reliable and objective benchmarking data it is possible to reduce losses caused not only by abandoned projects but also by the large scale of overrunning the time and costs of BSS D&EP execution.

Collecting and analysis of the benchmarking data concerning software projects most of all is aimed to discover and understand regularities applying to various projects of this type. It will be possible only on the condition that repositories containing benchmarking data about software projects will continue to be extended – with particular emphasis put on these projects, which are characterised by the exceptionally low effectiveness, i.e., business software systems development and enhancement projects.

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