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Factors of Effective Business Software Systems Development and Enhancement Projects Work Effort Estimation

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***Abstract*—**Majority of Business Software Systems (BSS) Development and Enhancement Projects (D&EP) fail to meet criteria of their effectiveness, what leads to the considerable financial losses. One of the fundamental reasons for such projects' exceptionally low success rate are improperly derived estimates for their costs and time. In the case of BSS D&EP these attributes are determined by the work effort, meanwhile reliable and objective effort estimation still appears to be a great challenge to the software engineering. Thus this paper is aimed at presenting the most important synthetic conclusions coming from the author's own studies concerning the main factors of effective BSS D&EP work effort estimation. Thanks to the rational investment decisions made on the basis of reliable and objective criteria it is possible to reduce losses caused not only by abandoned projects but also by large scale of overrunning the time and costs of BSS D&EP execution.

***Keywords*—**Benchmarking data, business software systems development and enhancement projects, effort estimation, software engineering economics, software functional size measurement.

I. Introduction

MAJORITY of application Development and Enhancement Projects (D&EP) fail to meet criteria of their execution effectiveness, what is proven by numerous analyses. As indicated by the results of the Standish Group study, success rate for such projects has never gone beyond 37% [1]. This US institution estimates that in case of more than 40% of application D&EP the planned time of product delivery is exceeded by nearly 80% on average and the estimated budget - by approx. 55% on average [2]. Also, it is worth mentioning the research carried out by government agencies in the USA indicating that 60% of software systems development projects overrun the planned completion time, whereas 50% of these projects overrun the estimated costs [3]. Similar – as to the general conclusion – data result from the analysis of IT projects being accomplished in Poland, indicating that approx. 48% of such projects went over the planned completion time whereas approx. 40% exceeded the estimated budget [4].

Analyses by T.C. Jones plainly indicate that those application D&EP, which are aimed at delivering Business Software Systems (BSS), have the lowest chance to succeed [5]. The Panorama Consulting Group, when investigating in their 2011 study the effectiveness of ERP (Enterprise Resource Planning) systems projects being accomplished worldwide, revealed that 61% of them were completed after the scheduled time whereas comparison of actual versus planned expenses has revealed that as many as 74% of such projects overran the planned budget [6]. Respondents indicated that there were significantly more companies with ERP project overruns in 2010 than there were in 2009. Interesting comparisons of resolution results, cost overrun, and time overrun, made by the Standish Group with regard to three types of order processing application D&EP, are presented in Table 1 [7].

TABLE I
COMPARISONS OF RESOLUTION RESULTS, COST OVERRUN, AND TIME OVERRUN FOR THREE TYPES OF ORDER PROCESSING APPLICATION D&EP

Resolution	New application development	Package application with modifications	Application modernization
Resolution results comparison			
Successful	4%	30%	53%
Challenged	47%	54%	39%
Failed	49%	16%	8%
Cost overrun comparison			
Below 20%	43%	22%	46%
20% to 50%	21%	36%	29%
51% to 100%	10%	29%	14%
Over 100%	26%	13%	11%
Average overrun	44%	47%	34%
Time overrun comparison			
Below 20%	38%	27%	59%
20% to 50%	19%	32%	21%
51% to 100%	30%	31%	12%
Over 100%	13%	10%	8%
Average overrun	44%	45%	29%

Source: [7, pp. 4-6].

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 [8]. 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. The above situation manifests itself in the difference in costs spent by various organizations on very similar applications that may be even fifteen fold [9].

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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 analyzed 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]).

Thus effective estimation of BSS D&EP cost and time, being of key significance to clients, encounters serious problems in practice. It results from the fact that objective and reliable BSS D&EP work effort estimation still appears to be a great challenge to the software engineering. That's why the goal of this paper is to present the most important synthetic conclusions coming from the author's own studies concerning the main factors of effective BSS D&EP work effort estimation.

The paper is structured as follows: in Section 2 practical approaches to BSS D&EP work effort estimation in the context of requirements for effective cost and time frame estimation are synthetically presented. Section 3 is devoted to the analysis of main factors of effective BSS D&EP effort estimation resulting from studies carried out by the author. In Section 4 the main conclusions coming from the author's surveys concerning the usage of BSS D&EP work effort estimation approaches by the Polish BSS providers are pointed out. Finally, in Section 5 the author draws conclusions and some open lines about future work with regard to the problem presented in the paper.

II. Approaches to Business Software Systems Development and Enhancement Projects Work Effort Estimation

One of the fundamental causes of low BSS D&EP success rate are improperly derived estimates for their costs and time. In the case of such projects the budget and time frame are determined by the work effort being spent on activities needed to deliver product, which would meet client's requirements. However, sufficiently objective and reliable BSS D&EP effort estimation still appears to be a great challenge to the software engineering.

Effective approach to the BSS D&EP work effort estimation should be characterized by the following required basic features (for more details see [13]):

- Not only it allows to control but also to plan project attributes, meaning that it may be used as a reliable basis of estimating in the relatively early stage of the project life cycle – as early as at the analysis stage it should be able to provide ballpark estimation of the necessary costs and time frame so that a client has rational grounds to make investment decision.
- It enables to carry out estimation from a client's perspective, thus allows to define project attributes in units being of significance to a client which, therefore it gives possibility to interpret the results in business language and promotes user's involvement in the project execution, which is of fundamental importance: from the very beginning of the Standish Group studies, user's involvement in application D&EP has been confirmed to be the most important success factor of such projects [1].
- Is independent of technology being used, therefore it enables to make comparison of various projects, being performed by various providers, at various times as well as to compare modules of the very same project employing different technologies.
- Takes into account the effort needed for completion of all project life cycle stages - not only the programming phase.
- Is coherent with economic definition of productivity, meaning that using more efficient programming language not only will reduce effort and total cost of the project but it will also reduce unit cost and increase productivity of project activities.
- Is universal, i.e., suitable for all software product categories.

Basic approaches used in practice for the BSS D&EP work effort estimation do not meet all these postulates, though. They first of all include:

- analogous estimating,
- decomposition methods (based on Work Breakdown Structure - WBS), also called engineer or bottom-up methods,
- expert methods (e.g., brain-storming, Delphi method),
- parametric extrapolation methods, also called empirical or algorithmic methods,
- delay estimates, also called "skeptic's method",
- so-called "price-to-win" technique,
- Parkinson rule.

"Price-to-win" technique and Parkinson rule may hardly be considered as having methodical grounds hence we did not use the term „methods" here. First of these two ways takes no notice of the product size and complexity whereas the effort does not depend on client's requirements but rather on client's budget to which the product is then being adjusted. What also is not recommended is the use of the approach known as the Parkinson rule, according to which „work expands to fill the available volume". In this case the effort is determined by the arbitrarily decided time frame and by the human resources available – and not by the objective evaluation criteria.

Expert methods require extensive experience in the field of project execution and with regard to the specific technology being used as well as they call for estimates being derived by several independent experts, whose knowledge is costly whereas gaining them over for the project is a difficult task. What's more, they are burdened with high risk: tests show that the ratio of the effort estimates, being calculated by experts from different business areas for the same project may be 1:6 or even 1:12 at the worst [14]. Analogous estimating, delay estimates and "price-to-win" – regardless of other drawbacks – may hardly be considered as offering possibility to derive reliable estimates as early as at the analysis stage of project life cycle. At this stage, method of analogous estimating comes in useful only as giving very general idea of the total costs; in the case of delay estimates it is *a priori* assumed that they negate the possibility of deriving reliable estimations in initial stages of project development whereas "price-to-win" most often leads to the cost underestimation since providers lower the cost deliberately in order to submit the cheapest offer. Bottom-up estimating methods require project to be split into detail activities, which is not always possible as early as at the beginning of the project life cycle. Moreover, the International Software Benchmarking Standards Group (ISBSG) studies reveal that the accuracy of effort estimations made with the use of this type of methods is lower comparing to the models based on software product size expressed in the so-called functional size units [15].

The latter are one of the parametric extrapolation methods, which are characterized by the fact that their utility depends on the unit chosen to express the size of software product. Techniques of BSS D&EP effort estimation built on empirical parametric models are based on benchmarking data coming from numerous similar projects that had been completed in the past and thus they generalize experience in terms of dependencies between the work effort and the software product size (for more details see e.g., [13], [16[, [17], [18]).

III. Main Factors of Effective Business Software Systems Development and Enhancement Projects Work Effort Estimation

Theoretical and practical analysis of the approaches to the BSS D&EP work effort estimation made by the author revealed that the most important factors of reliable and objective effort estimation include:

1. Estimation made on the basis of software product size (see also [12], [19]).
2. Software product size expressed in appropriate size units (see also [20], [21]).
3. Use of appropriate benchmarking data to adjust the estimation approach to a given organization's specificity (see also [13]).

A. Work Effort Estimation on the basis of Software Product Size

In the author's opinion the main reason for ineffective BSS D&EP work effort estimation is effort estimation made on the basis of resources whereas such planning activity should ground on the required software product size, which determines the work effort (see Fig. 1). "Measurement of software size (...) is as important to a software professional as measurement of a building (…) is to a building contractor. All other derived data, including effort to deliver a software project, delivery schedule, and cost of the project, are based on one of its major input elements: software size." [22, p. 149]. The parametric extrapolation methods are the only approach from approaches mentioned in Section 2 that are based on such assumption. However, the utility of such methods depends on the size unit used to express the software product size.

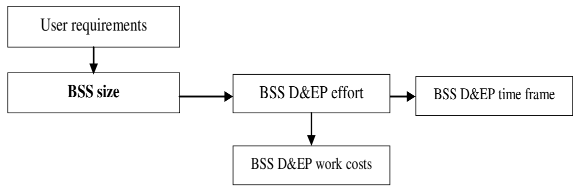

Fig. 1 Simplified model of dependencies between BSS D&EP key attributes and the size of project product

Source: Author's own study.

B. Appropriate Units of Software Product Size Measurement

Basic approaches to the size measurement of every software product may be reduced to perceiving it from the perspective of (for more details see [12]):

- Length of programs, measured by the number of the so-called programming (volume) units. These units most of all include source lines of code, but number of commands, number of machine language instructions are also taken into account. However, these units measure neither size of the programs nor their complexity but only the attribute of "program length" yet thus far these are them that in practice have been employed most often with regard to the software product size [22, p. 149].
- Software construction complexity, measured in the so-called construction complexity units. Most of hundreds of such measures having been proposed are limited to the program code yet currently these units are used mainly in the form of object points [22, pp. 155-156]. These points are assigned to the construction elements of software (screens, reports, software modules) depending on the level of their complexity.
- Functionality of software product, expressed in the so-called functionality units. They most of all include function points, but also variants based on them such as: full function points, feature points, and use case points. These points are assigned to the functional elements of software (functions and data needed to complete them)

depending on the level of their complexity – not to the construction elements as it was the case of object points.

Unit selected to express the software product size not only determines the kind of parametric extrapolation method but it also has deciding influence on the utility of such methods. Accordingly, methods based on the programming units do not meet any of the requirements presented above – except for versatility. On the other hand, methods based on object points do not define the software size in units, which would be of significance to a client since product construction complexity is of secondary importance to him. What from client's perspective appears to be primary software purpose is to support the functions he performs, which means that in fact this is the required software functionality that should be determining product construction complexity, and not conversely. Methods based on functionality units do not have limitations of this type, just the opposite – they meet almost all fundamental requirements, the only objection which may be raised concerns their versatility, whose degree varies depending on given technique of the so-called software Functional Size Measurement (FSM). Among their unquestioned advantages is software product size estimation (*ex ante* activity) and measurement (*ex post* activity) from the perspective of D&EP product functionality, being of primary importance to a client (for more details about FSM see [21]).

Many years' verification of various approaches to the estimation and measurement of software product size showed that what for now deserves standardization is just the concept of software functional size measurement. Due to the empirically confirmed effectiveness of such approach, it was in the last years normalized by the ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission), and turned into the six-part international standard ISO/IEC 14143 [23]. Five of FSM Methods (FSMM) have been now acknowledged by the ISO/IEC as conforming to the rules laid down in this standard, namely: (1) International Function Point Users Group (IFPUG) method [24]; (2) Mark II (MkII) function point method proposed by the United Kingdom Software Metrics Association (UKSMA) [25]; (3) Netherlands Software Metrics Association (NESMA) function point method [26]; (4) Common Software Measurement International Consortium (COSMIC) function points method [27]; and (5) FSM method developed by the Finnish Software Measurement Association (FiSMA) [28].

The FSMM standardized by the ISO/IEC differ in terms of software estimation/measurement capabilities with regard to different software classes (i.e., functional domains), but all of them are adequate for business software systems (for more details see [21]). What's more, practical usefulness of these techniques has been confirmed by many surveys, including e.g., those carried out by the State Government of Victoria [29] and International Software Benchmarking Standards Group [15], indicate that BSS D&EP, in case of which the FSMM were used for effort planning, are characterized by relatively accurate estimations. Studies by the State Government of Victoria indicate that pricing of BSS on the basis of product size expressed in functionality units results in reducing the average budget overrun to less than 10% – comparing with current average budget overrun amounting to approx. 55% [2]. The ISBSG report confirms these results: in the situation where the methods based on product functional size are employed in making cost estimation, in 90% of cases the estimates differ from the actual costs not more than by 20%, and among these very cases 70% are accurate to within 10%. Also analysis of the results of 25 studies concerning the reliability of the most important BSS D&EP work effort estimation methods, made by the author on the basis of the subject literature in [19], revealed that currently the highest accuracy of effort estimations is delivered by the parametric extrapolation methods based on software product size expressed in functionality units.

FSM methods, despite relatively high complexity, are used worldwide more and more often, clearly due to their proven effectiveness. For instance, in UK, the Mark II method is a method recommended by Central Computer and Telecommunications Agency (CCTA) in the execution of application D&EP for the needs of public administration. On the other hand, COSMIC method is a national standard in Japan and in Spain; this method has been listed also by the US Government Accountability Office in its "Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs" [30]. What's more, these methods are widely employed not only by providers but by clients as well [31].

C. Use of Appropriate Benchmarking Data

Thus, the FSMM standardized by the ISO/IEC provide sufficiently objective and reliable basis for BSS D&EP work effort, budget, and time frame estimating relatively early in the project life cycle yet on the condition that appropriate benchmarking data are available. Appropriate benchmarking data most of all mean data pertaining to the type of projects considered, being representative for this type, enabling one to obtain both rough estimates at the early stages of estimation process as well as more detailed estimates, in case of which one takes into account characteristics of the undertaken project and differences in the productivity of various project teams. Undoubtedly the best solution is a situation where BSS D&EP 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, on the basis of which are built general models indicating dependence of the BSS D&EP work effort on the product functional size.

M. Jørgensen suggests that three levels of effort estimation models adjustment should be distinguished, namely [32]:

- Low adjustment level: adjustment made by taking into account standard factors affecting the work effort related to the differences appearing between the estimated and typical project (e.g., in case of using the new supporting tool for the first time – adding 10% of total effort). At this level the organizational benchmarking data are not being analyzed.

- Medium adjustment level: adjustment made by using productivity specific to an organization, which replace standard factors affecting the work effort of typical project.
- High adjustment level: estimation models in the form of regression equations are calculated exclusively on the basis of benchmarking data specific to an organization.

From synthetic point of view, the most accurate BSS D&EP estimation process should include the following activities [33]:

1. Initial (early) estimation performed during project planning process, which may hold iterative and/or interdependent character, made, among others, on the basis of: client requirements, deliverables list, strategy of development/enhancement, skill and experience required, and first of all own organizational benchmarking data, along with evidence provided for the basis and results of estimation as well as for management approval.
2. Updating the estimates at major project milestones and at any necessary re-planning with the use of own organizational benchmarking data along with evidence provided for the basis and results of estimation as well as for management approval.
3. Measurement (verification) process performed during project monitoring and control process, which provides basis for collecting own benchmarking data in organizational repository, being especially designed for this purpose - those data enabling to derive dependencies specific to a given organization, taking into account fundamental characteristics of the project, most of all including: project purpose, business area, organization type, type of activities, size and experience of project team, programming language, hardware platform, development methods and tools, product type, and product functional size.

These activities should proceed under supervision of the scope manager being supported by the development team leads. As a result they should bring the following outputs: product functional size estimate, work effort estimate, time frame estimate, costs estimate, refined total life-cycle costs, actual history to be used in future estimation process, and basis of all estimates along with determining the degree of uncertainty in estimates considering first of all users' requirements completeness [33].

Although there are companies that have been collecting own benchmarking data for many years now, in reality, however, numerous BSS D&EP organizations had not been collecting them in a reliable and systematic manner, necessary to derive dependencies specific to them, which was proven in the research [34], whereas with regard to Polish providers of the dedicated business software systems – in surveys carried out by the author [35].

In the case of lack of adequate organizational benchmarking data one notices the usefulness of data repositories and models of general character (for more details see [13]). Naturally, one may also go back to the projects completed in a given organization and, having the sufficient documentation, derive necessary dependencies however with no doubt it is time-consuming. Repositories collecting general benchmarking data about application 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. Each of the tools supporting application D&EP estimation based on FSMM has such repository. Among exemplary tools offering possibility of estimating application D&EP attributes on the basis of product functional size may be numbered: *ISBSG Early Estimate Checker, ISBSG Reality Check, SPR KnowledgePLAN, SCOPE Project Sizing Software, SEER SEM, Function Point WORKBENCH, Software Metrics Manager, PQMPlus*, and many others. Benchmarking data are offered also by some organizations interested in the development of estimation methods – among them the repository of International Software Benchmarking Standards Group is worth paying particular attention to as comprising data on over 5 000 of application D&EP whose products are measured on the basis of FSMM [36]. 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 that ISBSG is making data on thousands of projects available to the software industry, it is becoming possible to make solid business decisions about software development practices and their results in terms of productivity and quality, ISBSG data is a valuable asset for the software industry and for all companies that produce software." [37].

IV. Business Software Systems Development and Enhancement Projects Work Effort Estimation in Poland

Surveys that aimed at analyzing the usage of BSS D&EP work effort estimation approaches by the Polish dedicated BSS providers as well as the reasons behind this *status quo* were conducted by the author of this paper in two research cycles: at the turn of the year 2005/2006, being the time of economic prosperity, and next at the turn of the year 2008/2009, that is in the initial stage of crisis and increased investment uncertainty associated with it (in order to observe changes, the author originally intended the research to be repeated after 5 years, however radical change in the economic situation worldwide and in Poland persuaded her to undertake it 2 years earlier). Their results were widely presented in [35].

Both research cycles were completed using the method of diagnostic survey: the first cycle analyzed responses given in 44 questionnaires (52 questionnaires were sent out) whereas the second cycle – responses given in 53 questionnaires (62 questionnaires were sent out). Questionnaires were distributed among various Polish dedicated BSS providers, both internal (IT departments in organizations) as well as external (for the most part from the SME sector), providing systems for the needs of financial institutions (banks, insurance) departments, trading companies and public administration institutions. In both cycles the overwhelming majority of responses were given by IT managers or project managers. Each questionnaire included about 30 questions validated by experts; most questions were of open or semi-open character and were divided into two main groups: concerning the usage of the work effort estimation approaches (answered by all respondents) and concerning the usage of the FSM methods (answered only by the respondents familiar with FSMM). It should be stressed that the research was limited only to organizations dealing with D&EP, whose products are dedicated BSS – thus analysis included neither software maintenance, support and integration projects, software package acquisition and implementation projects, nor other software products types.

With regard to the problem analyzed in this paper these surveys indicate that:

- Considerable part of the respondents (first cycle: 55%, second cycle: 47%) declares they do not commonly employ any of the methodology-based approaches to the BSS D&EP effort estimation, in most cases pointing to the "price-to-win" technique as the preferred estimation approach (not methodology-based) when providing software systems for government institutions, because legal regulations reward the cheapest offers. However, the level of using the BSS D&EP effort estimation methods (i.e., analogous estimating, decomposition methods based on WBS, expert methods, and parametric extrapolation methods) has increased over the analyzed time (from 45% to 53% of the surveyed providers).
- In both research cycles the respondents declared rather widespread usage of at least one of the effort estimation methods, mostly pointing to the expert methods, which are burdened with high risk (first cycle: 36%, second cycle: 43% of all respondents).
- FSM methods still place at the penultimate position among analyzed methods used for BSS D&EP effort estimation by the surveyed providers, however the level of using them has increased in the second research cycle (from 20% to 26% of all respondents).
- In both research cycles relatively low popularity of the FSMM results mostly from insufficient familiarity with such methods, but the FSMM awareness has increased over the analyzed time (from 27% to 34% of all respondents).
- Percentage of the respondents using FSM methods versus those familiar with them has increased slightly too (from 75% to 78%), which means that the overwhelming majority of those familiar with the FSMM are also employing them.
- In both research cycles as the main purpose of using the FSM methods was considered product size estimation in order to effectively estimate the work effort, costs and time frame for the initiated project.
- In both research cycles as the main advantages of the FSM methods were considered methods' objectivity and high usefulness, including most of all possibility to employ them at initial project stages at sufficient accuracy level of estimates, which helps increase the effectiveness of delivering the required functionality on time and within the planned budget. Disadvantages of the FSM methods include first of all high level of difficulty in using them.
- It happens relatively often that expert methods are employed along with FSMM. Fundamental reason why FSMM along with expert methods are employed is lack of sufficient resources of adequate own benchmarking data, which would allow for deriving dependencies specific to an organization.
- Thus in the case of using both the above mentioned methods to estimate BSS D&EP attributes as a rule are employed general benchmarking data, sometimes being corrected with standard effort-affecting factors (low adjustment level). Such approach usually is considered to be sufficient if it is necessary to resolve significant disagreements between several diverse experts estimations or if a client expects to be presented with general justification for estimation results.
- Several providers declared also using their own benchmarking data – they are used to calculate productivity of development/enhancement activities (medium adjustment level) on the basis of estimated product functional size. The surveys, however, revealed none case of high adjustment level of effort estimation model to the organization specificity. Apart from the lack of sufficient resources of adequate organizational benchmarking data it results also from the perception of such approach effort as excessive in relation to potential benefits.
- As indicated by surveyed providers, one of the fundamental advantages being a result of employing FSMM is possibility to profit from the out-of-organization knowledge and experience, that is from the general benchmarking data and parametric extrapolation models being derived on the basis of these data as well as possibility to compare estimation results gained on the basis of these methods with outside statistics, which is a considerable argument in the negotiations with clients.
- However, among providers declaring familiarity with FSMM one of the reasons why they stopped using it is lack of adequate organizational benchmarking data and at the same time lack of trust in general data. This is mainly users of FSMM who see the need to collect relevant own organizational data although majority among them do not possess yet a sufficient, as they perceive it, collection of such data.

Although the level of using work effort estimation methods by Polish BSS providers can be hardly considered high, increase in their popularity, however, may be possibly explained by the four main factors, namely: (1) increasing care about financial means in the times during and after recession; (2) growing competition on the market and increasing market globalization level; (3) growing awareness of clients therefore greater requirements concerning providing justification for the project costs and completion time offered by providers; and (4) standardization of the FSM concept and its several methods by the ISO/IEC.

V. Concluding Remarks

The goal of this paper was to present the most important synthetic conclusions coming from the author's own studies concerning the main factors of effective BSS D&EP work effort estimation. This was carried out on the basis of short presentation of the results of selected studies proving exceptionally low effectiveness of BSS D&EP, what unequivocally indicates a significant need to rationalize investment decisions made with regard to such projects, as well as on the basis of short presentation of practical approaches to the BSS D&EP work effort estimation in the context of requirements for effective cost and time frame estimation.

Theoretical and practical analysis of the approaches to the BSS D&EP work effort estimation revealed that the most important factors of reliable and objective effort estimation include: (1) estimation made on the basis of the software product size; (2) software product size expressed in appropriate size units, i.e., functional units; and (3) use of appropriate benchmarking data to adjust the estimation approach to a given organization's specificity.

The main reason for insufficiently effective BSS D&EP work effort estimation is effort estimation made on the basis of resources whereas such planning activity should be grounded on the required software product size, which in case of such projects determines the work effort. The parametric extrapolation methods are the only approach taking into account such assumption. However, the utility of such methods depends on the size unit used to express the software product size.

The right measure of software product size has been sought out for several decades now. Many years' verification of reliability and objectivity of various approaches towards software size measurement showed that what for now deserves standardization is just the concept of software size measurement based on its functionality – being an attribute of first priority to the client. Due to the empirically confirmed effectiveness of such approach, it was in the last years normalized by the ISO and IEC in the standard ISO/IEC 14143. There are about 25 variants of the FSM techniques having been developed, however only five of them have been now acknowledged by the ISO/IEC as conforming to the rules laid down in the ISO/IEC 14143 norm and certified as international standards. Results of numerous surveys indicate that the normalized FSMM provide sufficiently objective and reliable basis for BSS D&EP work effort, costs, and time frame estimating.

On the other hand, reliable estimation of project work effort, cost, and duration based on the product functional size requires benchmarking data, on the basis of which it is possible to derive necessary dependencies, which should be adjusted to the given organization's specificity. However, many BSS D&EP organizations have not been collecting so far their own appropriate benchmarking data in a reliable and systematic manner – in such case one may notice the usefulness of ever richer resources of benchmarking data, having been collected in special repositories that were created with the improvement of software processes in mind. Each of the tools supporting application D&EP estimation based on FSMM has such repository. Benchmarking data are offered also by some organizations interested in the development of estimation methods, e.g., ISBSG.

It is hard to compare conclusions coming from the author's surveys that aimed at analyzing the use of BSS D&EP work effort estimation approaches by the Polish BSS providers with the results of other studies carried out worldwide, as the author has no knowledge about studies having similar goals. Yet the fundamental conclusion brought by these surveys agrees with the general conclusion drawn by the Software Engineering Institute (SEI) on the basis of the research attempted to answer the question about today's approach to the measurement of software processes and products: "From the perspective of SEI's Software Engineering Measurement and Analysis (SEMA) Group, there is still a significant gap between the current and desired state of measurement practice. (…) Generally speaking, based on the results of this survey, we believe that there is still much that needs to be done so that organizations use measurement effectively to improve their processes, products, and services." [34, p. 29]. The author's surveys will be continued to keep observing the changes whereas the research area will be extended as much as possible to other Polish dedicated BSS providers and other economic BSS D&EP aspects.

Effective estimation of BSS D&EP product functional size, work effort, cost, and time frame increases the chance to reach its goal, i.e., on-time delivery of BSS being consistent with client's requirements without budget overrun. Since the more accurate estimation the lower the risk to go beyond estimates in reality. What's more, such assessment enables to get information about resources that are necessary to deliver product having required functions and features – and it should allow for quitting projects for which the chance of execution with the resources available proves low, or for correcting resources designed for the projects so that they are closest to the estimated values. Thanks to the more accurate investment decisions made on the basis of rational, objective and reliable criteria it is possible to reduce losses caused not only by abandoned projects but also by the large scale of overrunning the time and costs in the case of the BSS D&EP execution.

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