

## Economic Efficiency Analysis for Information Technology in Developing Countries

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**Abstract: Problem statement:** The introduction of Information Technology (IT) to government institutions in developing countries bears a great deal of risk of failure. The lack of qualified personnel, lack of financial support and the lack of planning and proper justification are just few of the causes of projects failure. Study presented in this study focused on the justification issue of IT projects through the application of Cost Benefit Analysis (CBA) as part of a comprehensive Economic Efficiency Analysis (EEA) of IT Projects, thus providing management with a decision making tool which highlights existing and future problems and reduces the risk of failure. **Approach:** Cost-Benefit Analysis (CBA) based on Economic Efficiency Analysis (EEA) was performed on selected IT projects from ministries and key institutions in the government of Jordan using a well established approach employed by the Federal Government of Germany (KBSt approach). The approach was then modified and refined to suit the needs of developing countries so that it captured all the relevant elements of cost and benefits both quantitatively and qualitatively and includes a set of guidelines for data collection strategy. **Results:** When IT projects were evaluated using CBA, most cases yielded negative Net Present Value (NPV), even though, some cases showed some reduction in operation cost starting from the third year of project life. However, when the CBA was applied as a part of a comprehensive EEA by introducing qualitative aspects and urgency criteria, proper justification for new projects became feasible. **Conclusion:** The modified EEA represented a systematic approach which was well suited for the government of Jordan as a developing country. This approach was capable of dealing with the justification issue, evaluation of existing systems and the urgency of replacing legacy systems. This study explored many of the challenges and inherited problems existing in the public sectors of developing countries which can not simply be resolved by the introduction of IT projects, but rather require more comprehensive solutions.

**Key words:** Economic efficiency, cost benefit analysis, developing countries, public sector, information technology, information systems, urgency criteria, qualitative relevance

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### INTRODUCTION

The introduction of Information Technology (IT) in the public sector in developing countries has been considered as an important issue by both researchers and practitioners in the field<sup>[1-3]</sup>. Many developing countries are now considering IT as a means to enhance the quality of services, to reduce the problem of redundancy of employees and as a means to reduce the high overhead cost of operations. However, many systems implementations have produced less than satisfactory results and have failed to meet the required objectives in both the private as well as the public sectors<sup>[1,4,5]</sup>. The lack of financial resources, the lack of

experience in IT and the deficiency in comprehensive planning are only some of causes that contribute to the failure of IT in the public sector. Successful implementation of Information Systems (ISs) requires both careful planning along with precise justification<sup>[6-9]</sup>. The objective of this study therefore is to develop a criterion for justification of ISs through the application of Economic Efficiency Analysis (EEA) for government IT projects in developing countries. The developed criteria should represent a systematic approach which can be easily adopted and implemented by government institutions. To establish such a criteria, Cost-Benefit Analysis (CBA) based on EEA is to be performed on selected cases from ministries and key

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institutions in the government of Jordan using a well established approach employed by the Federal Government of Germany (KBSt approach)<sup>[8,10]</sup>. The criteria is then to be modified and refined to suit the needs of developing countries. The resulting criteria must be designed so that it captures all the relevant elements of cost and benefits both quantitatively and qualitatively and must include a set of guidelines for data collection strategy. More importantly, the developed criteria must represent an applicable approach based on the general objectives for the implementation of IT in government institutions.

**General objectives for using IT in government institutions:** In order to successfully apply EEA for IT projects in government institutions, it is essential to consider the general objectives specified by these governments to ensure whether existing or planned ISs are in line with these objectives. A set of objectives has been set by the Federal Government of Germany, which may work well with developing countries. These objectives are:

- Improvement of the technical administrative effectiveness and the quality of the fulfillment of administrative tasks
- Avoiding risks of the continuation of support of old administrative procedures and functions by replacing them with new procedures
- Improvement of the short and long term economic efficiency which can be measured by CBA
- Extension of the use of telecommunication facilities to improve the internal and external communications
- Enhancement of the services to citizens by more specific services according to needs with more transparency using efficient yet simplified procedures
- Improvement of work conditions for public employees through the IT-introduction considering measures such as the reduction of “dog works”, empowerment of employees and reduction of the division of labor

**Economic Efficiency Analysis (EEA):** Economic efficiency is a systematic approach for evaluating the relative worth of proposed projects by manipulating both quantified and non-quantified information<sup>[11,12]</sup>. It is in the narrow sense, the relation between results (performance and benefits) and the required inputs (cost). A project or a solution in place is efficient if the sum of benefits is greater than the costs expressed in measurable monetary quantities.

An important part of economic efficiency which focuses on quantitative information is CBA. It is the process of assessing the net value of a project and can be applied to justify the worth of proposed IS projects, comparing and ranking different alternative solutions of a project, or can be used as an evaluation tool for existing systems<sup>[13-16]</sup>.

Performing an effective CBA, however, can be a challenging task. The problems begin with identifying and locating the sources of the cost and the benefits, hence the visible costs may constitute only a small portion of the total cost of the project. The hidden or indirect costs if neglected will result in an inaccurate analysis of CBA. Benefits on the other hand, can be easily identified but are difficult to quantify and, therefore, are difficult to measure in monetary value.

Applying CBA to government institutions<sup>[19,20]</sup> especially in developing countries poses a great challenge for many reasons among of which are: the lack of documentation and resources, the unavailability of special budgets for IT, the unavailability of a clear and unified set of objectives for IT, the misconceptions regarding CBA for IT where some officials think the advantages of IT are too obvious to require CBA, the use of IT by some managers for the sole purpose of self image rather than increase in efficiency and last but not least, the centralized structure of the public institutions which makes it difficult to associate the cost and the benefits of a project to a given specific workplace or department. In addition; most of government IT projects in developing countries can be characterized as none-profit service oriented projects with benefits that are mainly qualitative in nature.

**Considerations used in the application of EEA to IT:** In order to arrive at a systematic approach for EEA, which can overcome many of the problems presented earlier; certain measures have been considered which include the following points:

- The introduction of IT has a varying influence at the different levels of the institution<sup>[5]</sup>. In particular, work at other places and in other departments as well as clients (companies, citizens) are affected by the use of new IT facilities
- The difficulty of determining and measuring qualitative benefits such as the quality of the execution of administrative task and functions, the change in the motivation of employees, or effects on clients
- Old systems in public institutions are being replaced through the use of IT, thus providing a basis for comparison between new projects and old applications using EEA

		Scope of EEA			
		Effects on a work place	Effects on the work in one ore more department	Effects on the organisation as a whole	External effects on other administrative units clients, citizens
Dimensions of Impact	Qualitative-strategic criteria				
	Urgency criteria				
	Cost-benefit-analysis				

Fig. 1: Levels of impact and location of measurement

- Cost and benefits do not appear at the same time and location. For instance, benefits appear after users have adjusted to the new facilities and have gathered experience to use them efficiently. Another example is the heterogeneous distribution of costs and benefits over various departments (computer unit, user and clients)

These considerations led to the EEA concept, which specifies explicitly the following (Fig. 1):

- The scope of impact areas or levels where effects appear and can be located and measured as well
- The dimensions of measurement, i.e., the question whether the impact can be reflected in specific quantitative monetary terms or whether important consequences of the IT-introduction can be expressed only with qualitative criteria

The EEA model suggests identifying and measuring effects of IT-facilities on four levels: (i) at one specific working place, (ii) the IT facilities may also affect the work in one or more department, (iii) the organization as a whole is influenced and (iv) external effects on other institutions, clients or citizens can appear.

Using the above considerations along with impact measurement dimensions, results in a comprehensive EEA, which include of the following measurement:

- Economic Efficiency in the narrow sense, i.e., the comparison of quantitative monetary costs and benefits based on the concept of CBA, which represents an instrument for the quantitative comparison of the cost and benefits of an investment. The practical CBA model comprises and distinguishes between two categories:
  - One time costs and one time benefits
  - Consideration of current or running costs and savings including all direct and indirect costs/savings

Whereby, benefits in both categories are mainly understood as savings of costs:

- Urgency of a project: The relevance of this criteria stems from efforts in the field of IT risk assessment<sup>[13,14]</sup>. Urgency in the frame of this analysis is understood as a justification for IT projects in cases where, for example, new laws and regulations are going to be changed and related IT-facilities need to be upgraded accordingly to avoid the risk of interrupting the execution of administrative functions. Unjustified high work loads of the staff or cancellation of user support by the vendor are other examples. This criterion is measured using a pointing system
- Qualitative-strategic relevance of IT facilities: The qualitative-strategic relevance of the concerned IT facilities is proposed to be measured also by a point system. The reasons for the introduction of this dimension of impact are:
  - The discussed problem to express all important effects of IT in quantitative monetary terms as well as the limitation of the used CBA approach
  - The reference of this concept of effectiveness to the mentioned objectives of using IT, like contributions of a project to national priorities, improvement of the working conditions, contributions to enhancements in the quality of administrative work or improvements in the services provided to the citizens

## MATERIALS AND METHODS

**Working steps of EEA:** The practical work to prepare EEA is accomplished in several phases:

- Collection of all relevant documents, technical specifications of the IS/IT solution itself, to

identify the solution and to determine the scope of the subject of analysis

- Planning for data collection is to be carried out using a standard EEA questionnaire form consisting of all the possible attributes of cost and benefit. Relevant attributes concerning the system under study are selected resulting in a general checklist which specifies what type of system effects should be considered and collected (Fig. 2)
- This checklist has to be converted to a specific one. Not all criteria selected can be expressed quantitatively in monetary values. The distinction between these and qualitative criteria leads to different requirements of data collection. So, for the preparation of data collection, the planner has specified the related activities
- During the phase of data collection several sources are to be exploited, these are:
  - Data on costs and certain benefits can be gathered with the help of administrative departments or its accounting units.
  - Costs of equipment mentioned in the project plan are to be collected by contacting qualified vendors
  - Other monetary units especially indirect cost and benefits can be derived by using standardized values for salaries following the required grades for example. Other monetary data such as time savings of citizen are to be identified and calculated with the help of qualified resource persons in the public sector
- In a final step a report will be compiled. It contains:
  - Filling of the CBA tables with the collected monetary figures, their aggregation over a five

years period and as a last step the calculation of the Net Present Value (NPV)

- Filling the tables to estimate urgency and qualitative-strategic relevance and the calculation of the final score in both dimensions

There are several options for the use of EEA report as a material for planning and decision making, in particular, it can be used in:

- The IT framework guidelines
- The discussion of decisions to execute a certain project.
- The evaluation of the project plan to introduce changes corresponding to the outcome of the EEA.

**When to apply this analysis?:** According to the KBSt regulations<sup>[8]</sup> the EEA should be applied on:

- Existing IT facilities to ensure the management of the proper implementation of the solution or to signal further needs for action.
- Every IT-project proposals an EEA has to be presented as one major mean for the management to justify the project execution and in particular the use of financial resources.

**Practical Framework For EEA:** The implementation of this approach tries to ease and simplify the related research and provide tools to enable computer analyst to carry out the analysis<sup>[3,8,11]</sup>. The approach consists of: data collection, presenting results of EEA and using the report for decision making.

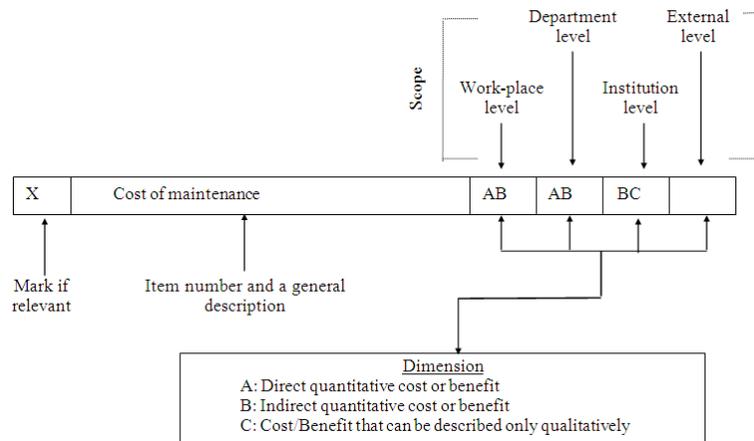


Fig. 2: Explanation of one of the entries of the standard questionnaire

**Data collection:** To ensure a high quality data and accurate economic efficiency analysis, the proposed study is being designed to employ a well-organized yet a simple and practical data collection phase which includes two major steps:

- Selection of relevant criteria
- Setting up a plan for data collection

**The selection of relevant criteria:** In this phase, the determined scope of analysis and its standardization using unique forms is selected. There is no need to elaborate or develop relevant categories of cost and benefits or criteria for urgency and qualitative aspects. All potentially relevant aspects are compiled in one questionnaire as a standard for the possible scope of investigating costs, benefits and other aspects of impact of the IT-facility under consideration. The questionnaire contains a list of categories covering the following criteria:

- One time cost and benefits
- Current costs and repeated time savings/ benefits
- Criteria for urgency
- Qualitative-strategic criteria

Using this questionnaire-form we can walk through all possible categories and select and mark those that appear to have an impact on the project under study. The selection of relevant criteria is a project-dependant process and may differ from one type of project to another. Once the list of relevant criteria is ready, the next step is to determine the scope and the dimension of each criterion to identify the sources of data required for the analysis and to classify the measurement type of the criteria as direct quantitative, indirect quantitative, qualitative, or a combination of each. Figure 2 shows an example of one of the entries in the questionnaire form, indicating that, the "cost of maintenance item" has been checked as a relevant cost item and it has an impact on the work-place, department and institution levels. This impact has been classified as direct/indirect quantitative for both the work-place and the department levels and as indirect quantitative/qualitative for the institution level. In other words, the sources of cost for maintenance are located at all levels within the institution (no external effect) and this cost can be measured directly such as in the case of a maintenance contract, indirectly such as calculating the cost of some specific service provided by the technical staff, or qualitatively to describe certain aspects of maintenance such as the lack of staff.

**Setting up a plan for data collection of cost-benefit analysis:** Once the relevant criteria are selected and their scope and dimension are determined, the next step is to design a well-organized plan for data collection. The plan would include the following points:

- Identify the members of the data collection team: The team can be divided into two groups one for collecting data for the one-time cost/benefit and the other for collecting the running cost/benefit data
- Divide the criteria of cost/benefit equally in terms of effort required for data collection among the members of each group
- Members of each group identify the source and location for each cost/benefit criteria and sets up a plan which includes contact persons, time and period for each visit, the mile-stones required to complete the task assigned
- Special forms and tables (invoice-like forms) have to be prepared (if they don't exist) by the members of each group to record down and organize the data for ease of calculation
- Once the data has been collected it should be verified carefully. Inconsistencies, duplicate cost or benefits, inaccuracy of estimated figures, missing data are only few of the problems that have to be resolved

The methods used for the computation of indirect cost/benefit can be a cause of inconsistency if differs between groups. The entire data collection team must agree on the computation methods and must check the formulas used. Standard data used in the calculation (e.g., average income per capita or average salary of a government employee) have to be consistent.

**Collecting data on non-recurring costs and benefits:** This part of data collection is concerned with determining the one-time costs and benefits. It includes all costs and benefits associated with planning, development, system introduction and installation. The details and breakdown of the calculation of each cost-benefit criteria are usually included in separate tables (invoice-like table)<sup>[8]</sup>.

**Collecting data on current costs and benefits:** In this part, data regarding current (running) cost and benefits is collected or estimated and then formulated. Current cost and benefits are those costs and benefits which are repeated yearly throughout the life cycle of the project. The study presented in this report consists of four different criteria for current costs and benefits; each cost/benefit category should be described in separate

tables to show the distribution of cost/benefit over the lifetime of the project.

**Presenting the results of EEA for decision making:** Once the data is collected, verified and tabulated, the results of the analysis are presented in a final report containing a number of summarized tables along with the required calculations. The final report consists of a table for the non-recurring (one-time) cost/benefit, a table for the current or running cost/benefit, the NPV for the project, the final scores for the urgency and strategic criteria, a set of graphs representing the results of CBA and a conclusion with recommendation.

**Calculation of the present values and the NPV:** The concept behind the Present Value (PV) is to consider the time value of money (referred to as discount rate)<sup>[7,13-16]</sup>. Thus the value of money that have to be paid in the future is actually less than its value today (PV). So when estimating costs and benefits especially for long period of times, it becomes necessary to use the PV of money. NPV is determined by subtracting the accumulated present cost of a system from its accumulated present benefits. The Discount Rate (DR), PV and NPV can be calculated by<sup>[10,19]</sup>:

$$DR = \frac{1}{(1+R)^T} \quad (1)$$

$$PV = DR * FV \quad (2)$$

$$NPV = IV + \sum_{t=1}^T \frac{Cost - Benefit}{(1+R)^t} \quad (3)$$

Where:

R = The yearly interest rate

FV = The future value

IV = The initial investment

T = The period of the project measured in years

Using the above formula, if the result is positive it means that the discounted accumulated benefits are greater than that for the cost. Thus a project with a negative present value would signify a loss over that period of time.

**Using the report for decision making:** The realization and the implementation of any proposed project depends on the approval of management. However, when it comes to investing large sums of money in IT, top management officials are usually hesitant to

approve such projects especially when resources are limited and when budget cuts plans are being implemented. Management requires full justification of any proposed project. They even go further than that by requiring assurances that the proposed projects will be successful. The framework presented in this study has been designed to provide management with detailed justification of a given IT project by considering the following:

- The non-recurring cost: The EEA of some given project may produce positive results, however if the initial investment for that project is too big and the available budget cannot handle this cost, the project may be rejected or at least postponed for some time
- The running cost/benefits: One of the objectives of IT project would be the reduction of running or operation cost for the system. Questions that must be asked here regarding running cost are:
  - Does the new project reduce the annual running cost of the system?
  - If it does, at what point of the project life cycle would the savings appear?
  - If the running cost is not reduced, would it remain the same as the old system or would it exceed it? In both cases, does this system promise to satisfy new objectives and high quality standards of operations which where not supported by the old system? In other words, is this increase in running cost justifiable or not?
  - Would the annual budget of the institution handle the increase in running costs?
  - Is NPV for the project positive (accumulated benefits using discount rates exceed the accumulated cost) or not? If not, is that due to the large initial investment? Are there agencies that would assist in the development of the project in terms of donating equipment or services?
- The Urgency of the proposed project: The final results (score) of the urgency criteria are presented in the final report as a percentage. This score depends both on the points received and the assigned weight for each urgency category. It is up to management to interpret this percentage as urgent or not. It is also the decision of management to weigh the importance of the entire urgency criteria against the outcomes of the cost-benefits results

- The strategic criteria are also presented as a percentage just like the urgency criteria. In some cases, a strategic criterion is assigned a higher weight than any other parts of the EEA. A project which scores high in the strategic criteria and at the same time results in savings and benefits, which exceeds the development and running cost, is considered a candidate for approval by management
- In most cases studied there has been no special budgets allocated for computer resources. Thus, it was difficult to upgrade the existing systems in addition to the difficulty of controlling the operating cost of such systems
- The lack of documentation for existing system made it difficult to collect data and statistics. Inaccurate or contradictory data can be a source of misleading cost/benefit analysis results. Proper documentation methods which are based on international standards must be enforced to produce efficient cost/benefit analysis

## **RESULTS**

A complete set of well documented procedures were developed covering four aspects of EEA including initial cost/benefit, operational cost/benefit, urgency criteria and qualitative analysis. A strategy and set of guidelines for performing data collection was also included. These procedures, along with the data collection guidelines were then applied to four public institutions in Jordan, namely, Prime Ministry, Ministry of Trade, Ministry of Planning and the General Budget Department. The results of the application of EEA to the mentioned institutions were discouraging at first, but when analyzed, important lessons were learned. The results can be summarized as follows:

- The accumulated cost of introducing and operating IT in government institutions for the majority of cases appear to be greater than the accumulated benefits. This was evident by the negative NPV for such cases
- Despite the Negative NPV, there was clear reduction in the operating cost for the cases studied starting from the third year onwards of the systems life cycle. However, these benefits were limited when adding the non-recurring cost (initial investment cost)
- Most of the existing systems were not fully utilized in the automation of the required procedures. There was a lack of computer equipment, lack of software and lack of supporting staff
- It was evident from the case studies the lack or inefficient training and computer awareness programs for users, technical staff and for management
- Systems were implemented in many cases without long term planning and without having a clear vision of the objectives of IT. In some cases new equipment were installed on top of existing old hardware which made such systems difficult to operate and maintain
- Commitment of top administration officials towards IT showed to have great impact on the success of IT projects and systems. Some systems were implemented then stopped for a number of years then reinstated again with the change of administration. Other systems lacked proper equipment and remained so, for years until administration was changed
- There is a clear lack of communication between existing systems within the same institution and between other institutions which makes it difficult to share information. This was caused by the different and incompatible computer platforms implemented at these institutions
- The introduction of IT to the government institutions did not appear to have any effect on the reduction or reorganization of employees. On the other hand, the number of employees increased because of the addition of the system support staff. The cost of employees therefore appeared to be much greater than those benefits expected as a result of IT

## **DISCUSSION**

The result of the application of EEA experimentally on several case studies showed a challenging picture for the public sector management and the IT specialists. The current IT introduction leads in many cases to a situation in which finally the costs of the administration are significantly higher than before. Low benefits and low contributions to other objectives are also significant. Based on the results obtained, a number of issues must be addressed here:

- Cost of labor in the public sector of developing countries is usually much lower than that in the more industrialized countries, thus dramatically affecting the outcome of the EEA of a given project in terms of work-time saving as well as the

reduction of excess workforce. This situation suggests that if potential gains are not evident as for those projects in industrialized countries, emphases are then to be placed on other issues such as reduction of cost on tax payers, clients and on the issue of relocating employees, rather than on the issue of work-time saving directly

- Even when client's savings and quality of service are given a high priority in the evaluation of IT projects in developing countries, potential gains and benefits may not be realized without comprehensive solutions including Business Process Re-engineering for the entire workflow system of public institutions. Narrowly designed solutions will not achieve considerable benefits
- Inherited in the public sector of developing countries, is the resistance of change in staffing. When reduction of excess employees is not possible, other means must be explored such as relocation of employees and changing qualifications through re-training
- It is rather difficult, not to say impossible, to achieve the efficient and effective introduction of IT in the public sector only by decentralize initiatives in some ministries or other public authorities without the development of comprehensive and general features of a national IT infrastructure, such as a data communication infrastructure for the government, central efforts to clarify responsibilities to execute certain administrative functions, specific investment in networks as prerequisites for modernization efforts on the institutional level, clear priorities

### **CONCLUSION**

The application of CBA alone to the public sector institutions in developing countries does not provide management with a clear picture for decision making. CBA results in most cases were negative indicating infeasible projects. However, when CBA is applied as a part of a more comprehensive frame work (EEA), better decisions can be made. The proposed EEA approach not only measures the feasibility of new projects but also evaluates the feasibility of operation and maintenance of existing legacy systems. The Urgency criteria also plays an important role in the decision making process, by highlighting the dangers of continuing to operate an existing inefficient system. We can clearly conclude that IT projects for the public sector of developing countries should not be evaluated merely using CBA or other monetary measures. Other aspects of evaluation must be included such as

qualitative and urgency criteria. This study helped in highlighting many of the deficiencies inherited in the public sector such low employee wages, lack of training, lack of documentations, lack of systems utilization, lack of comprehensive planning, among many others.

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