Economic Efficiency Analysis for Information Technology in Developing Countries

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ABSTRACT

This paper presents the results of a study in the application of Economic Efficiency Analysis (EEA) to Information Technology (IT) in Developing Countries. Several case studies were selected from key institutions in the government of Jordan in an attempt to derive a systematic and practical approach for EEA which can be adopted and implemented by the public sector in developing countries.

Components of the study focusing both on quantitative as well as qualitative measures along with a well-organized data collection strategy are discussed in detail. Experience learned, results, conclusions and a set of recommendations are presented as they relate to case studies selected.

Keywords: Economic Efficiency, Cost Benefit Analysis, Developing Countries, Public Sector, Information Technology, Information Systems, Urgency Criteria, Qualitative Relevance.

1. Introduction

The introduction of Information Technology (IT) in the public sector in developing countries has been considered an important issue by both researchers and practitioners in the field [1,2,11,12]. Many developing countries are now considering information technology 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[7,9,18,19,25]. 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 requires both careful planning along with precise justification [3,8,10,14,15,17,20,24].

The objective of this study, therefore is to develop a criteria for justification of information systems through the application of economic efficiency analysis 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 is to be performed on selected cases from ministries and key institutions in the government of Jordan using a well established approach employed by the Federal Government of Germany (KBST approach) [16]. 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.

1.1 General Objectives for using IT in Government Institutions

In order to successfully apply economic efficiency analysis for IT projects in government institution, it is essential to consider the general objectives set by these governments to ensure whether existing or planned information systems are in line with these objectives. A set of Objectives has been set by the Federal Government of Germany
which should work well with developing countries. These objectives are:

1. Improvement of the technical administrative effectiveness and the quality of the fulfillment of administrative tasks.

2. Avoiding risks of the continuation of support of old administrative procedures and functions by replacing them with new procedures.

3. Improvement of the short and long term economic efficiency which can be measured by cost-benefit analysis.

4. Extension of the use of telecommunication facilities to improve the internal as well as communication with external clients or institutions.

5. Enhancement of the services to citizens by more specific services according to needs with more transparency using efficient yet simplified procedures.

6. 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.

2. Economic Efficiency Analysis

Economic efficiency is a systematic approach for evaluating the relative worth of proposed projects by manipulating both quantified and non-quantified information[14]. It is in the narrow sense the relation between results (performance, benefits) and the required inputs (cost). A project or a solution in place is efficient if the sum of benefits is greater than the inputs expressed in measurable monetary quantities.

An important part of economic efficiency which focuses on quantitative information is Cost-Benefit Analysis (CBA). It is the process of assessing the net value of a project and can be applied to justify the worth of proposed information system projects, comparing and ranking different alternative solutions of a project, or can be used as an evaluation tool for existing systems [6,13,14,21,22,23].

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 [4,5] 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 to the mentioned problems, 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.

2.1 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:

a) The introduction of IT has a varying influence at the different levels of the institution[8]. 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.

b) 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.
c) 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.

d) 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, clients).

These considerations led to an EEA concept, which specifies explicitly:

a) the scope of impact areas or levels where effects appear and can be located and measured as well as

b) 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 to identify and measure effects of IT-facilities on four levels:

1. at one specific working place
2. the IT facilities may also effect the work in one or more department
3. or the organization as a whole is influenced
4. eventually 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 the following measurement:

1. **Economic Efficiency** in the narrow sense, i.e. the comparison of quantitative monetary costs and benefits based on the concept of Cost-Benefit-Analysis (CBA) which represents an instrument for the quantitative comparison of the cost and benefits of an investment.

The practical CBA-approach comprises and distinguishes between:

- 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.

2. **Urgency of a project**

The relevance of this criteria stems from efforts in the field of IT risk assessment [6,13]. 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

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**Figure 1. “Levels” of impact and location of measurement**
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 criteria is measured using a pointing system.

3. Qualitative-strategic relevance of IT facilities

The qualitative-strategic relevance of the concerned IT facilities are 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 and
- 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.

2.2 The Working Steps of EEA

The practical work to prepare a EEA goes to several phases:

1. 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.
2. 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 (refer to Fig. 2).
3. 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 your data collection as a next step you have specify the related activities.

4. During the phase of data collection several sources are to be exploited:

- Data on costs and certain benefits can be gathered with the help of administrative departments or it’s accounting units.
- Cost of equipment mentioned in a plan are to be collected by contacting a vendor.
- 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.

5. In a final step a report will be compiled. This 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.
- filling the tables to estimate urgency and qualitative - strategic relevance and the calculation of the final score in both dimensions.

6. There are several options for the use of EEA-report as material for planning and decision making:

- it can be used in the IT-Framework Guidelines
- or more directly in a discussion of decisions to execute a certain project
- or to evaluate a project plan to introduce changes corresponding to the outcome of the EEA.

2.3 When to apply this analysis ?

According to the KBST regulations[16] 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.

- Secondly for 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.
3. The practical Framework for Economic Efficiency Analysis

The implementation of this approach tries to ease and simplify the related work and provide tools to enable computer technicians to carry out the analysis[15].

3.1 Data collection

To ensure 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 as follows:

1. Selection of relevant criteria and
2. Setting up a plan for data collection.

The coming section will elaborate on these steps as they are applied to each part of the study.

3.2 The determined scope of analysis and it's standardization by unique forms - The Selection of Relevant Criteria

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:

1. One time cost and benefits
2. Current costs and repeated time savings/benefits
3. Criteria for urgency
4. 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. (Refer back to Section 2.1 for explanation of Scope and Dimension.)

![Figure 2. Explanation of one of the entries of the standard questionnaire](image)
Figure 2 shows an example of one of the entries in the questionnaire form. As illustrated in the figure, we find that this item (cost of maintenance) 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 for example.

### 3.3 Data collection for cost benefit analysis

The data collection phase of the cost/benefit analysis consists of two major parts. The collection of data for the one-time cost/benefits and the data collection for the running cost/benefit. The procedure for the data collection follows the same two steps described above. First, the selection of the relevant criteria, and second, setting up a plan for data collection. The procedure and the steps are described in detail in the next sections.

#### 3.3.1 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:

1. 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.
2. Divide the criteria of cost/benefit equally in terms of effort required for data collection among the members of each group.
3. 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.
4. 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. These tables can be computerized.
5. 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 (eg. Average Income Per Capita or Average salary of a government employee) have to be consistent.

#### 3.3.2 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) [15].

#### 3.3.3 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 is then described in separate tables to show the distribution of cost/benefit over the lifetime of the project.
4. Presentation of the Results
Once the data is collected, verified, and tabulated, the results of the analysis is 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 Net Present Value 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.

4.1 Calculation of the Present Values and the Net Present Value
The concept behind the Present Value is to consider the time value of money (referred to as discount rate) [6, 13, 14, 22,23]. Thus the value of money that have to be paid in the future is actually less than its value today (present value). So when estimating costs and benefits especially for long period of times, it becomes necessary to use the present value of money. Net Present value is determined by subtracting the accumulated present cost of a system from its accumulated present benefits.

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\text{Discount Rate} = \frac{1}{(1 + \text{Yearly Interest Rate})^{\text{Year}}} \\
\text{Present Value (PV)} = \text{Discount Rate} \times \text{Future Value} \\
\text{Net Present Value} = \sum_{\text{Year}=1}^{\text{Year}=} \text{PV Benefit} - \sum_{\text{Year}=1}^{\text{Year}=} \text{PV Cost}
\]

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.

4.2 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 Information Technology, 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 study presented in this paper has been designed to provide management with detailed justification of a given IT project.

1. 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.

2. 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:
   - 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 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 Net Present Value 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?

3. The Urgency of the proposed project: The end results (score) of the urgency criteria is 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.

4. The Strategic criteria is also presented as a percentage just like the urgency criteria. In some cases, strategic criteria 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.

4.3 Findings and Conclusions

a) The accumulated cost of introducing and operating information Technology in government institutions for the majority of cases appears to be greater than the accumulated benefits. This was evident by the negative Net Present Value for such cases.

b) Despite the Negative Net Present Value, 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).

c) One problem which has contributed to the lack of benefits of existing systems was that most such 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.

d) Another major problem was the lack or inefficient training and computer awareness programs for users, technical staff, and for management.

e) Systems were implemented in many cases without long term planning and without having a clear vision of the objectives of information technology. In some cases new equipment were installed on top of existing old hardware which made such systems difficult to operate and maintain.

f) 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.

g) 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.

h) 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.

i) There is a clear lack of communication between existing systems within the same institution and between other institution which makes it difficult to share information. This was caused by the different and incompatible computer platforms implemented at these institution.

j) 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.

k) The results of the qualitative criteria were not as high as expected due to the many points described above.

4.4 Issues to be addressed

The results of the case studies as well as the application of EEA experimentally on other cases shows 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. Our conclusions drawn from this impression
leads to these recommendations:

a) There is one significant difference between industrialized countries and developing countries which always has to be considered in the frame of introducing new technologies in the Third World: the relation between cost of labor to the cost of technology differs remarkably. For example, if the introduction of IT facilities in the Federal Government of Germany causes the saving of 20% of work time of an average employee, monetary benefits will appear in just few months. The same effect may not take place or will require years to be materialized for the introduction of the same IT-solution in Jordan, since the price of one desktop computer may be higher than a one years’ salary of a public employee in Jordan.

This situation gives reason to think of the implications for IT - concepts and their assessment in a country like Jordan. We don’t think that these differences lead to a general justification of in-efficient solutions, since there are tax payers in Jordan as well and their concern of cost efficient administrative services can not be neglected. Therefore the more reasonable conclusion is to think of a different strategy of IT-introduction in Jordan’s public sector. Such a strategy might locate potential gains of IT in another fields and with other priorities than for instance, in the public sector of European countries.

b) More attention should be paid to the outcome of single solutions before they are implemented. To ensure a positive outcome of technical modernization efforts ex ante evaluations like EEA or just CBA as well as more comprehensive methods like the IT-Framework-Guidelines should be used.

c) It seems that the solutions designed and applied in the past were very narrow and tend to computerize easy to formalize parts of the work flow instead of approaching procedures in a comprehensive manner and a more radical way. One reason may be the concept of system analysis in practice which has to be complemented by Business Process Re-Engineering methods and other approaches to exploit the potential gains of IT. Furthermore, there are certain obstacles to realize benefits of IT-solutions in the Jordanian administration by the similar applications than in Europe, since the number of clients or applications is to low to achieve considerable savings compared to a comprehensive IT investment.

d) As also experienced in fields other than IT, the management is afraid or resisting for other reasons to deal with changes in staffing. In spite of this behavior, it can be shown by other countries experience that IT potentials are gained by reduction of staff and changes in qualifications. This by the way does not mean automatically to lay off employees. In particular the status of the Jordanian administration shows the needs to cover certain functions by more efforts and hands. So, comprehensive planning could lead to a proper transfer of staff saved by IT to other important administrative fields.

e) It is rather difficult, not to say impossible, to achieve the efficient and effective introduction of IT in the public sector only by decentral 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 further modernization efforts on the institutional level, clear priorities, etc.

f) These results and conclusions also can show a need for comprehensive efforts to “re”-train the technicians as well as the management in this field.

g) New laws and referendums have to be passed to consider the computer generated outputs as legal documents. The lack of such laws have resulted in duplicate and unnecessary efforts which in some cases required the work to be done both on the computer system and manually so that to be considered legal.

h) A comprehensive national frame-work for the introduction of IT in governmental institution has to be established. Such a framework will specify the guidelines and recommendations for taking advantages of the new technology and will unify the methods of implementation of IT projects in government.
References


