# IT Measurement in the Hospital Industry – A Case Study

SATYA N. PRATTIPATI

UNIVERSITY OF SCRANTON

C. CARL PEGELS

STATE UNIVERSITY OF NEW YORK AT BUFFALO

## ABSTRACT

Assessing the impact of information technologies (IT) requires measurement of the level of deployment of IT (computerization) and the outcomes. The lack of comparable IT measures is believed to be one of the reasons for the lack of clear evidence of the impacts of IT. In a research study to evaluate the impact of computerization on unit costs and employment levels in hospital departments, the authors used a unique methodology to measure computerization in hospital departments. Computerization was measured as a composite measure of the extent of use of computers to perform different tasks and the importance of the tasks. The case study explains the methodology used to measure computerization and illustrates it with actual application to one of the hospital departments. The study also examines the applicability of this methodology to other industries and situations.

## DESCRIPTION OF THE PROBLEM

In a research study conducted by the authors to evaluate the impact of computerization on unit costs and employment levels in hospital departments, the authors were faced with the problem of defining, as well as measuring "computerization" in a hospital department. This paper describes the problems in defining, and measuring computerization and a unique methodology used by the authors to measure "computerization."

The goal of the study was to evaluate the effect of computerization of hospital departments on the unit costs and employment levels of hospital departments. The study was designed as a cross-sectional study with a sample of 60 hospitals located in the western and central regions of New York state. The underlying hypothesis was that those hospital departments with higher levels of computerization would have lower levels of unit costs and employment, than those departments with lower levels of computerization. In each hospital, 12 departments were considered for the study. Thus the sample consisted of 60 admission departments, 60 medical records departments and so on. The unit of analysis was a specific hospital department.

The first problem the authors faced was how to define computerization. What do people mean when they say that their admissions department is more computerized than the other hospital across town? Do they mean that they spend more money on computers than the other hospital, or do they mean that they have much more powerful and sophisticated computer systems, or do they mean they use the computers to perform more tasks than the other hospital? In addition, the authors had to come up with a uniform measure of "computerization." This measure had to be consistent and comparable across all the 60 hospital departments.

Many research studies used several surrogate measures to represent computerization. A summary of the surrogate measures used in a selective number of studies is given in Table 1. A review of Table 1 indicates that many researchers have used the amount of resources spent on computers (i.e dollars, manpower, number of CPUs, or the number of software packages in use, etc.) as measures of computerization (input measures). Others used computer capital as a measure of computerization. These measures represent only the amount of resources spent on acquisition and possibly the operating costs of the computer system. These measures do not reflect the importance of the tasks for which the resources are used. Also they do not reflect the extent of the use of the computer system. In an interview in Information Week [10, p:16], a K-Mart IS manager (who requested anonymity) was quoted as saying "Competitors have lesser systems but utilize them better. ... We get a system that's a real Cadillac, but teach

TABLE 1

**Input and Output Measures Used in Selected Studies on the Impact of Information Technologies**

| Reference | Unit of Analysis | Input Measure (computerization) | Output Measure ( outcomes ) |
|---|---|---|---|
| Alpar and Kim (1990) | Firm (759 banks) | Total IS expense labor capital time deposits | productivity |
| Banker and Kauffman(1988) | Firm (508 branch banks) | Presence of ATM Regional ATM | competitive advantage |
| Bender (1986) | 132 insurance companies | Total IT expenses | cost efficiency |
| Brynjolfsson and Hitt (1993) | 380 large firms | Computer and non-computer capital, IS and non-IS labor | Output as measured by sales |
| Cron and Sobol (1983) | 138 surgical wholesalers | No. of software applications | profitability |
| Harris and Katz (1991) | 40 life insurance companies | IT expense ratio IT cost efficiency ratio | operating cost efficiency |
| Loveman (1988) | 60 small manufacturing companies | Total IT capital stock | productivity (ave. labor) |
| Osterman (1986) | 40 service and manufacturing industries | No of mainframes and cpus | productivity |
| Pentland (1989) | Department 1100 IRS agents | Laptop computer use | productivity (hours/audit) output quality |
| Strassmann (1990) | 38 service companies | Various IT ratios weighted differently | % return to shareholders |
| Venkatraman and Zaheer (1990) | Individual (78 insurance agents) | Electronic integration with insurance carriers | Productivity (# of policies) Effectiveness (premiums/comm) |

people to drive VWs)." This comment reinforces the argument that just spending money on IS resources is not enough. What is more important is the extent of the use of the IS resources to perform important tasks. In addition, in this period of rapid technological developments and declining prices for IT products, the amount of money spent on IT resources may not correctly reflect the extent of computerization or the sophistication of the technologies. Furthermore, some organizations contract out their IS operations and there may not be a uniform way of accounting for the IS expenses across the organizations.

In other studies, the installation and implementation of a specific computer/ software system (like a specific commercial software to manage Medical Records) was considered as an indicator of computerization. The results of such studies would be applicable only to those organizations where the

specific systems were implemented. Many hospitals have many different systems installed and as such the presence or absence of a specific computer system would not be a comparable measure of computerization across hospitals.

Several researchers used measures like "usage of computer systems" and "user satisfaction" as surrogate measures of computerization (Eion-Dor [7], Zmud [19], and Srinivasan [16]). The "usage" and "user satisfaction" measures, were criticized for not considering the importance of the tasks for which the computers were used (Ginzberg [8], Keen [11], Bruwer [4]).

Computer systems (hardware, software, and communication systems) are used to perform certain tasks in a department. No matter how sophisticated the computer systems are, they have to be used to perform certain tasks. If they are not used (because of complexity or user dissatisfaction), they can not have any effect on the final outcomes (unit costs, employment levels). Thus "usage" is an important indicator. In addition, the type of tasks for which the computers are used is also important in terms of the effects on final outcomes (unit costs, employment levels). If computers are used just for word processing or for some other tasks which may not be relevant in terms of their effect on final outcomes, then the level of usage of computers will not matter. Hence, it is also important to consider the level of importance of the tasks for which the computers are used.

Based on these arguments, the authors conceptualized the "extent of computerization" as a composite measure of both the usage of the computer system and the importance of the tasks for which the system is used. This measure overcomes some of the deficiencies of the measures used in other studies. It reflects the extent of use, as well as the importance of the tasks for which the computers are used, and does not depend on any specific computer system.

A hospital department may have one or more types of computer systems (hardware, software, and communication systems) installed or some outside contractor may be providing the computer services. The availability of computer systems can be considered as initial treatments which will result in the intermediate outcomes such as the use of computer systems to perform several tasks of different levels of importance. The "extent of computerization" reflects the extent of the use of the computer systems to perform different tasks and the importance of the tasks for which the computer systems are used. The term "computerization" was used as a convenient label to represent the composite factors of usage and the importance of the tasks. As pointed out earlier, "computerization" may mean different things to different people. Computerization as conceptualized here, is applicable to the limited purpose of this study only. The "extent of computerization" was used as an independent variable, with a likely effect on the "final outcomes" (unit costs, and employment levels) along with other independent factors. The procedure used to measure the extent of computerization in each hospital department is explained in the next section.

## Methodology to Measure Extent of Computerization

The procedure used to determine the extent of computerization in each department, consisted of the following four steps.

1. Identification of all the tasks in the department that could be performed with the help of a computer at least to some extent.
2. Determination of the relative importance of each of the identified tasks in the department.
3. Determination of the extent of use of computers to perform each of the identified tasks.
4. Computation of the "extent of computerization" for each department.

**Step 1 - Identification of the tasks**: In this first step, all the tasks in each department that can be performed with the help of a computer at least to some extent should be identified. In order to keep the list meaningful and manageable, the department tasks that could be done with the help of a computer (at least to some extent) should be classified as broadly as possible. For example, one of the tasks identified for the admissions department was "patient information collection." This task is a combination of several activities such as asking the patient (or a patient's friend) to complete a form, entering the information into a computer, and other related activities. The list of the tasks that could be computerized in each of the twelve departments in a hospital was readily available in the AHIS Component Catalog (Leonard et al. [12]), which was developed (with the help of a federal grant) from a survey of 1000 randomly selected hospitals and nearly 300 software vendors.

**Step 2 - Relative importance of the tasks**: The second step was to determine the relative importance of the tasks identified in each department. The relative importance of each task was determined based on the information provided by the department managers. Questionnaires were mailed to the department managers, asking them to rank order the tasks (that could be computerized) in their departments in terms of their relative importance for achieving organizational goals. The actual computation of the rank indicating relative importance is explained in step 4.

**Step 3 - Extent of computerization of the tasks**: The IS managers in each hospital were asked to indicate to what extent each task in each of the twelve departments was performed with the help of a computer system. This information was collected from IS managers through personal interviews. The IS managers were asked to indicate the

extent of computerization of each task on a four point scale ranging from **"none"** to **"large extent."**

**Step 4 - Computation of extent of computerization in each department**: The actual computation of the computerization score of the admissions department in one hospital is illustrated below.

The AHIS catalog (Leonard, et al. [12]) listed seven tasks in the admissions department which could be performed (at least to some extent), with the help of a computer. These seven tasks were specified in a questionnaire which was mailed to the managers of the admissions departments of all the sixty hospitals which participated in the study. The managers were asked to indicate any other tasks for which they might be using computers. The managers were requested to rank the seven specified tasks and any others they might have added in terms of importance for achieving organizational goals. The managers were asked to rank the most important task as 1 and the next most important task as 2 and so on. If the managers felt that two or more tasks in the department were equally important, then they were asked to give equal ranks to those tasks. Twenty-three managers (out of sixty) returned the questionnaires. The average rank order scores for each task in the department is shown in Table 2. The task having the lowest average score is considered as the most important and is given the top rank of 1. The task with the highest average score is considered as the least important and is given the lowest rank of 7. The top-ranked task is given a task importance weight of 2 and the lowest ranked task is given a task importance weight of 1. The remaining five tasks are given task importance weights between 1 and 2 at equal intervals. The weights do not reflect the absolute levels of importance, but only the relative order of importance of the tasks. The same task importance weights were used for all the Admission Department tasks of all the hospitals in the sample.

The IS managers of each hospital were asked (in a personal interview) to indicate to what extent each of the specified tasks in the admissions department was being performed with the help of computer systems. She or he was requested to place a check mark under one of the four categories for each task. These categories were *"none"* when no part of the task was performed with the help of a computer, *"small"* when nearly a third of the task was performed with the help of a computer, *"some"* when between a third to two thirds of the task was performed with the help of a computer, and *"large"* when more than two thirds of the task was performed with the help of a computer. These categories were given extent-of-computerization weights (**C**), from 0 through 3, i.e., 0 for "none," 1 for "small," 2 for "some," and 3 for "large."

The response of one IS manager for an admissions department is shown in Table 3. The task importance weights (**I**) of each task are also shown in Table 3.

The computerization score for each task is calculated by multiplying **I with C** as shown in Table 3. For example, it may be seen from Table 3, that "Patient information collection" was computerized to some extent, i.e., **C = 2**. Its task importance weight (**I**) is also 2. The computerization score for this task is 2 x 2 = 4. The computerization scores are calculated and shown for each task. Total computerization score (**TC**) for the department is 11.83. The maximum possible computerization score is calculated by assuming that all the tasks in the department are performed with the help of a computer to a large extent, i.e. for all the tasks. From Table 3 it may be seen that the maximum possible computerization score (**Max**) for the admissions department is 31.5. Extent of computerization in the department is computed as a percent of total computerization score (**TC**) to the maximum possible computerization score (**Max**) of the department. As shown in Table 3, the extent of computerization of this admissions department is 37.55%. It should be noted that this measure should not be considered as an absolute measure. It does not mean that 37.55% of the departmental tasks were computerized. The measure is an ordinal measure and should be used for comparative purposes only.

**Validation:** To compare the extent of computerization measures, with the conventional measures (based on data-processing expenses), an aggregate computerization score (HOSPSCORE) for each hospital was computed. The hospital computerization measure (HOSPSCORE) was computed by using the weighted average score of computerization of

**TABLE 2**

**Tasks Ranked by Department Managers**

| Task | Average Score | Rank | Weight (I) |
|---|---|---|---|
| Patient Inf. Collection | 1.22 | 1 | 2.00 |
| Patient transfers/ discharges | 2.83 | 2 | 1.83 |
| Census | 2.87 | 3 | 1.67 |
| Pre-admission work-up | 3.52 | 4 | 1.50 |
| Bed assignment | 3.70 | 5 | 1.33 |
| Management Reports | 4.60 | 6 | 1.17 |
| Elective admission forecasting | 4.85 | 7 | 1.00 |

Source: Average scores were computed from the data collected from the Admissions Department managers of 23 hospitals in upstate New York.

**TABLE 3**

**Admissions Department**

**Computation of the Extent of Computerization**

| Import weight (I) | Name of the task | Extent of computerization (c) NONE (0) | SMALL (1) | SOME (2) | LARGE (3) | Score (C x I) | Maximum possible (3 x I) |
|---|---|---|---|---|---|---|---|
| 2.00 | Patient inf. Collection | | | x | | 4.00 | 6.00 |
| 1.83 | Transfer/discharges | | | x | | 3.66 | 5.49 |
| 1.67 | Census | | x | | | 1.67 | 5.00 |
| 1.50 | Pre-adm. work-up | x | | | | 0.00 | 4.50 |
| 1.33 | Room assignment | | x | | | 1.33 | 4.00 |
| 1.17 | Management Reports | | x | | | 1.17 | 3.51 |
| 1.00 | Elective admission forecasting | x | | | | 0.00 | 3.00 |
| | Total | | | | | 11.83 | 31.50 |

**I** = Importance weight of each task

**C** = Extent of Computerization of each task

**Score:** Computerization score of each task (**I x C**)

**Maximum Possible Score:** Maximum possible computerization score of each task (**3 x I**)

**Example:** Maximum possible score for the task "Census": 3 x 1.67 = 5

Total Computerization Score for the department (TC) = 11.83

Maximum Possible Score for the department (Max) = 31.50

Extent of Computerization of the department = (TC/MAX) * 100 = (11.83/31.50) * 100 = 37.55%

the twelve hospital departments used. The weights for each department were based on the employment level of each department. The aggregate computerization scores of a hospital might be different if the weights were based on other criteria. The correlation coefficients between HOSPSCORE and different components of hospital data processing expenses are shown in Table 4.

As discussed before, the data processing expenses reflect the availability of computer resources and not necessarily the extent of use of such resources or the importance of the tasks for which those resources were used. The derived hospital computerization measure was a broader measure reflecting the availability of the computer resources, extent of use and the importance of the tasks for which the computers were used. Certainly there will be a fair amount of correlation between different components of data processing expenses and hospital computerization (as both of them reflect the availability of computer resources), but there will not necessarily be a very close **one-to-one** relationship between the measures. The correlation co-efficients between hospital computerization and the components of data processing expenses range between 0.57 and 0.68 which indicate a moderate association but not a strong relationship.

## GENERALIZABILITY OF THE METHODOLOGY

We suggest the following guidelines to determine whether the method used by us can be used in other studies to measure computerization.

**1. Unit of analysis:** The IT impacts can be analyzed at the economy level, industry level, the firm level, the department level, and at the individual level. The methodology used in this study is suitable for use at the department or at the individual levels. It is practically impossible to develop a composite measure of computerization consisting of the ex-

TABLE 4

**Correlation Coefficient between HOSPSCORE and**

| | |
|---|---|
| Data processing salaries | 0.62 |
| Data processing other costs | 0.57 |
| Data processing total costs | 0.58 |
| Data processing costs per bed | 0.68 |

(**HOSPSCORE:** extent of computerization in a hospital)

tent of the use of computers and the importance of the tasks, at higher levels (firm, industry, and economy). Because of interdepartment linkages and communications within an organization, it is not possible to develop a list of tasks that reflect these communication linkages. At the firm level, many researchers used several surrogate measures related to the amount of resources spent on IT. For example, Alpar and Kim [1], Bender [3], and Harris and Katz [9] used IT expenses as a surrogate measure of computerization. Brynjolfsson [5] and Loveman [13] used computer capital as a measure of computerization.

At the individual level the impact of specific software, hardware, or a computer system is usually analyzed. For example Pentland [15] examined the impact of the use of laptop computers on the productivity of IRS agents. Availability of the laptop computer to the IRS agent was considered as the measure of computerization. It was assumed that all the IRS agents who had a laptop computer were using it in the same way (for similar tasks) and to the same extent. The method used by us can be applied to this situation, to develop a composite measure reflecting the extent of the use of the laptop computer and the importance of the tasks for which the laptop is used. This will involve additional time and effort to collect data.

**2. Industry type:** The methodology used in this study can be used to measure computerization in well-defined departments in any industry which is homogeneous to a large extent. The departments in the industry should be comparable across the industry and should perform uniform sets of tasks. For example, universities and colleges with similar departments such as Admissions, Registrar's Office, Student Accounts, etc., are ideal for applying this methodology. Some other industries where this methodology can be used are local governments, savings banks, small and medium-sized insurance companies which focus on a narrow group of products, etc. This methodology cannot be used in industries consisting of firms with diverse operations because it will be difficult to identify uniform sets of tasks for the departments. For such diversified industries surrogate measures like the level of deployment of IT resources should be used.

**3. Type of Information Systems:** The methodology used by us is applicable mainly to traditional transaction processing systems which involve pre-defined tasks which are uniform across the industry. This methodology is not appropriate for other types of systems such as strategic information systems, and the systems where the applications evolve over a period of time depending on the user's interest and creativity. These systems introduce a lot of variability in the use and as such cannot be compared across the departments.

**4. Identification of Tasks:** Identification of tasks that could be computerized in each department may appear to be a big hurdle. The tasks should be defined as broadly as possible. For example, "Management Reports" is a task included in the list of tasks specified for a hospital admissions department. This task is a combination of several other activities. Identification of such broad categories of tasks in each department should not be difficult. Such a list of tasks may be readily available in the departmental list of duties/ responsibilities.

## Contributions to the Management of Information Technologies

Information Technology managers have been finding it difficult to objectively justify the large amounts of investment in IT due to the lack of clear evidence of the impacts of IT. Lack of such clear evidence has been attributed to the deficiencies in the measurement of IT inputs (computerization) and the outcomes. The IT managers can use the methodology used in our study to develop comparative measures of computerization which can be compared with other similar organizations.

Each company can also use this method internally to determine the maximum possible level of computerization and actual level of computerization for each of its departments. This information can be used for planning and resource allocation purposes. Companies frequently allocate more resources (based on previous year's budgets) to departments which have already been computerized to a large extent, ignoring the needs of other departments which are only partially computerized. If the actual level of computerization and the maximum possible level of computerization are known, then it is possible to use the information to allocate adequate computer budgets to those departments which need them the most.

The computerization scores will also help management in evaluating the effective use of the computer resources. If computerization scores decline, in spite of the availability of more computer resources (as compared to previous years or with other organizations ), it indicates either inadequate use of the computer systems or use of the computer systems for less important tasks. The computerization scores will alert

management to the need to examine the reasons for low scores and take appropriate action.

How to define and measure "computerization" is a practical problem faced by every IT professional who is interested in the impacts of IT. We explained how we measured "computerization" at the department level. We hope that our methodology will provide some useful insights to others who may be interested in measuring computerization.

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## ABOUT THE AUTHORS


***Dr. Satya N. Prattipati*** *is an Associate Professor in the department of Operations and Information Management, at the University of Scranton, at Scranton, Pennsylvania. He holds a Ph. D. in Management Systems from the State University of New York at Buffalo. Dr. Prattipati has been engaged in a variety of teaching and research activities in Management Information Systems, Technology Management, and Operations Management. His primary research interests are on the impact of computers and information technologies on organizations and productivity, electronic data interchange, and MIS curriculum.*

***Dr. C. Carl Pegels*** *is Professor of Management Science and Systems in the School of Management, State University of New York at Buffalo. He holds a Ph.D. in Management from Purdue University. Dr. Pegels has been engaged in a variety of teaching and research activities in such diverse areas as strategic management, management information systems, operations management, and other functional areas. Dr. Pegels has published over 60 papers in academic and professional journals. he has also authored or co-authored* Systems Analysis in Production Operations, *(Gordon and Breach, 1976),* Systems Analysis in Health Care *(Praeger Publishers, 1978),* Health Care and the Elderly *(Aspen Systems, 1980),* Japan vs. the West — Implications for Managment *(Kluwer, Boston, 1984),* Quality Circles in Health

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