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Choosing the right amount of healthcare information technologies investments

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ABSTRACT

Objectives: Choosing and justifying the right amount of investment in healthcare information technologies (HITECH or HIT) in hospitals is an ever increasing challenge. Our objectives are to assess the financial impact of HIT on hospital outcome, and propose decision-helping tools that could be used to rationalize the distribution of hospital finances.
Design: We used a production function and microeconomic tools on data of 21 Paris university hospitals recorded from 1998 to 2006 to compute the elasticity coefficients of HIT versus non-HIT capital and labor as regards to hospital financial outcome and optimize the distribution of investments according to the productivity associated with each input.
Results: HIT inputs and non-HIT inputs both have a positive and significant impact on hospital production (elasticity coefficients respectively of 0.106 and 0.893; R^2 of 0.92). We forecast 2006 results from the 1998 to 2005 dataset with an accuracy of +0.61%. With the model used, the best proportion of HIT investments was estimated to be 10.6% of total input and this was predicted to lead to a total saving of 388 million Euros for the 2006 dataset.
Conclusion: Considering HIT investment from the point of view of a global portfolio and applying econometric and microeconomic tools allow the required confidence level to be attained for choosing the right amount of HIT investments. It could also allow hospitals using these tools to make substantial savings, and help them forecast their choices for the following year for better HITECH governance in the current stimulation context.
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1. Introduction and objectives

It has become almost impossible to make a strategic decision without involving information technology (IT) in modern hospitals [1]. For example, the new 2009 American Recovery and Reinvestment Act (ARRA) regarding Health Information Technologies (HITECH or HIT) gives strong incentives concerning high technology investments and especially electronic health records (EHRs) in US hospitals [2]. However, HIT continues to increase expenditure on lines for which nearly all decision makers believe that clear profitability has not been demonstrated [3]. Difficulties in capturing the impact of IT in national economies have first been expressed by Economy Nobel Prize winner Robert Solow's in a New-York Times 1987 interview: "*You can see the computer age everywhere but in the productivity statistics*". If there is widespread agreement about the importance of health information systems (HIS), the per-

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ceived lack of financial benefits raises the recurrent problem of justifying the associated investments and deciding on the appropriate amount of money to spend on IT. The result is that IT investments will inevitably be too low in the opinion of chief information officers (CIO) and always too high for chief executive officers (CEO). It has as a consequence become essential to quantify accurately the added value of appropriate IT investments in the healthcare sector [4].

Relationships between IT and hospital activities are indeed complex and the economic impact of new IT investments is difficult to grasp. To perform this task, the most common tools available are accounting methods like cost benefits analysis, net present value and internal rate of return [3,5–10]. These return-on-investment (ROI) methods can be applied to almost every investment project of any kind. Cost-benefit analyses [4,11–13] mainly emphasize the indirect earnings (e.g., quality and continuity of care, users' satisfaction, and process optimization) transformed into a monetary value of implementing a particular clinical information system component (e.g., computerized physician order entry (CPOE), clinical decision support systems (CDSS) or picture archiving and communications systems (PACS)) [1,3,14–18]. To achieve the best results these methods have to accumulate an exponentially increasing number of variables which might result in them failing as they become overly complex. In most cases, as the accuracy required increases, the amount of effort needed to feed the method rather than working the project also increases. Furthermore, all these financial methods, when used to evaluate a future investment, tend to be systematically biased against innovation [5,19]. As Christensen said in the January 2008 Harvard Business Review about their exclusive use "*they divert resources away from investments whose payoff lies beyond the immediate horizon*" [20]. In addition, all studies using accounting ROI reach their limits by focusing only on specific, identified and targeted types of benefits, neglecting the overall added value of the project on a strategic level. Only a handful of studies have attempted to measure overall earnings resulting from the integration of the different HIS components into a global portfolio or strategic approach [13,6,21,22]. Isolating and trying to measure the value added by a single project, like a PACS acquisition and deployment, is akin to assessing the value contributed by the cheese to a pizza. As Computer world columnists pointed out "*the idea that there are IT projects must be abandoned. There are only projects targeted at improving business processes, developing new products or services, delivering more efficient customer service or improving some other aspect of business performance*" [23].

Thus, many decision makers rely only on classic financial techniques that do not necessarily capture all the business benefits of their IT investment [24] and the contradictory results of some of these studies frequently lead hospital managers to make decisions solely on the basis of expected indirect benefits and/or empirical evidence.

A complementary approach to respond to this issue is provided by the set of tools emerging from econometric research. Econometrics is concerned with the development and application of quantitative and statistical methods to the study and elucidation of economic principles [25,26]. These methods can be extended from the macroeconomic level to the level of individual businesses to analyze the overall impact of particular investments in a global portfolio perspective as validated in prior research on industrial business [5,22]. In a preliminary study of 17 French acute-care hospitals, we observed a positive and significant relationship between IT investment (including capital and labor) and hospital productivity over an 8-year period (1998–2005) [21]. The results also showed that the expected benefits from the investments made were directly related to the integration level of the HIS: the higher the integration level, the greater the benefits. Another econometric study, based on a much larger but heterogeneous set of two thousand US hospitals, showed that higher levels of IT investment correlate with improved hospital cost performance [22]. This study also showed that IT acquisitions are cost-additive until a "critical mass" is achieved, at which point the relationship becomes neutral for a period of time but ultimately turns positive. Another interesting result is that there is a natural lag between technology implementation and the emergence of benefits. Cost reductions can be made in the same year as the IT acquisition, but generally it took 2–5 years to break even [22].

This paper explores the relationships between hospital financial outcomes and IT and non-IT inputs in a longitudinal study of 21 university hospitals. The objectives are (1) to assess the respective links between IT and non-IT inputs and hospital outcomes; (2) to assess the predictive capacity of an econometric model in an homogenous group of structures; (3) to measure the technical substitution relationship between IT and non-IT investments; and (4) to compute the optimized proportion of IT inputs versus non-IT inputs to get the best incomes for an hospital.

2. Materials and methods

2.1. *Production functions*

The economic approach of capital efficiency is generally represented by the ratio of production divided by capital expenditure [26]. A large ratio indicates better capital efficiency, leading to a greater output [27–29]. In the econometric field, sensitive data on this efficiency are provided by the utilization of a production or cost function. A production function links the growth and productivity of an enterprise to the elements, or production factors, used to generate products or services [30]. A mathematical relationship is established between the production (output) and the factors put together to obtain it (inputs). The American economist Paul Douglas and the mathematician Richard Cobb made a major step forward by proposing a non-linear function linking yearn or output (Y), capital (K) and labor (L) [30,31]. The initial studies with this function undertaken in 1930 particularly concerned the industrial sector, and since then it has been applied in all economic sectors seeking efficiency. In 1956, Nobel Prize winner Robert Solow enhanced the function by introducing a new factor known as the Solow residual (A) that is traditionally regarded as a marker of technology level [32]. The Solow production function can be expressed as

$$Y = AK^{\alpha}L^{\beta} \quad (1)$$

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