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Reliability and validity issues in analysis of IT spending using IT managerial control ratios

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Abstract

Purpose – The purpose of this paper is to critically evaluate the practice of IT cost benchmarking using IT managerial control ratios. First, numerous reliability and validity issues that this practice is plagued by are discussed. Second, recommendations on addressing some of these reliability and validity issues are also proposed.

Design/methodology/approach – This is a conceptual paper that draws on literature utilizing IT managerial control ratios to discuss various reliability problems associated with these measures and also makes use of IT strategy theory to challenge the validity of common interpretations of IT managerial control ratios.

Findings – This study explains that IT managerial control ratios are subject to numerous reliability and validity issues. The reliability issues arise from the inherent volatility of some of the variables used in these ratios and difficulties that executives have in providing a reliable estimate of those variables when they are approached by market research firms. The validity issues arise from the fact that high and low values of these ratios are subject to different and, at times, somewhat orthogonal theoretical interpretations.

Practical implications – IT managerial control ratios are often at the heart of important capital allocation decisions as well as studies which form important stakeholders' perceptions regarding the business value of IT. These important uses of IT managerial control ratios should not be carried out without understanding the reliability and validity issues discussed in this paper.

Originality/value – While IT managerial control ratios are used extensively in benchmarking and research, very few researchers and practitioners possess a full understanding of the reliability and validity issues associated with these measures. This can potentially lead to sub-optimal capital allocation decisions and erroneous findings in studies. This paper provides a comprehensive overview of these issues and recommends possible remedies.

Keywords Information technology strategy, Benchmarking, Organizational performance, Management information systems, Justification, Investment analysis, Interpretation, Framework, IS leadership, IT cost, IT spending, IT budget

Paper type Technical paper

Introduction

IT managerial control ratios (such as IT budget/revenues, IT budget/operating expense, IT budget/employees) are used extensively by both practitioners and researchers. Practitioners use these ratios in IT cost benchmarking – the practice of comparing IT spending against industry averages or companies known for their "best in class" information systems (IS) organizations (Computer Economics, 2013). Researchers use these ratios as measures of organizational IT spending in studies investigating the link between IT and various and measures of organizational performance, such as profitability and cost efficiency (Han and Mithas, 2013; Harris and Katz, 1991; Kobelsky *et al.*, 2008, Mahmood and Mann, 1993; Mitra and Chaya, 1996; Weill, 1992). Thus, IT managerial control ratios are often at the heart of important capital allocation decisions (Kobelsky *et al.*, 2008) as well as studies which form

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important stakeholders' perceptions regarding the business value of IT and value of IS as a discipline (Kohli and Grover, 2008).

Unfortunately, these two important uses of IT managerial control ratios are often plagued by poor understanding of properties of these ratios. IT managerial control ratios, while being a simple and parsimonious measurement of IT investment, are also subject to a number of reliability and validity problems. The reliability problems arise from the choice of a particular combination of numerator and denominator variables and the way values of these ratios are obtained from companies. Moreover, interpretation of what these IT managerial control ratios actually measure is subject to some ambiguity – something that raises concerns over validity of IT managerial control ratios as measures of IT spending relative to size. Both types of issues can potentially lead to erroneous decisions in relation to IT budgets.

This paper relies on a review of existing literature on IT cost benchmarking and IT payoff studies to educate both researchers and practitioners about the reliability and validity issues related to some of the most commonly used IT managerial control ratios. First, this paper provides a formal definition of an IT managerial control ratio and lists commonly used numerator and denominator variables used in IT cost benchmarking and research on the value of IT. Second, this paper discusses how these ratios are used in IT costs benchmarking and in studies attempting to link IT spending to organizational performance. Third, various reliability issues associated with commonly used numerator and denominator variables are discussed. Fourth, this paper argues that interpreting values of IT managerial control ratios is subject to some ambiguity, as various theoretical explanations of high and low values of these ratios are possible. The general literature on IT strategy is used to formulate different (and, at times, orthogonal) interpretations of high and low values of IT managerial control rations. This paper concludes with some final remarks regarding the usefulness of these ratios as measures of IT spending.

IT managerial control ratios

Mathematically, an IT managerial control ratio of a firm f can be expressed as the relationship with IT spending variable in the numerator and organizational size variable in the denominator (Nikkinen and Sahlstrom, 2004):

$$\beta = \frac{y}{x},$$

where y is the annual IT spending variable; x the organizational size variable; and β the organizational IT spending relative to size.

A variety of numerators and denominators has been used to measure IT spending relative to size (see Table I).

IT managerial control ratios accomplish two related goals: they serve as measures of organizational IT spending relative to size and they control systematic size differences among companies so that comparisons can be made. First of all, IT managerial control ratios serve as a parsimonious quantitative measurement instrument to obtain information about individual companies and industries. At the company level, a ratio can inform about the extent to which an organization relies on IT to support its operations (McFarlan *et al.*, 1983). Similarly, at the industry level, a ratio can inform about the degree to which IT is utilized within an industry. Second, dividing an IT

expense variable by an organizational size variable controls systematic size differences among companies (Lev and Sunder, 1979). Control for size differences is necessary so that comparisons can be made among companies of different size. There is some disagreement as to which of the two goals mentioned above is of primary importance (Barnes, 1983; Horrigan, 1983). However, it is clear that at least for comparison purposes, the two goals are mutually dependent (Lev and Sunder, 1979). A value of an IT managerial control ratio of an individual company does not provide any useful information unless it is compared to values of other ratios (e.g. value of an average ratio within an industry), but a meaningful comparison cannot be made unless size is controlled for. This is accomplished by dividing an IT spending variable by an organizational size variable.

IT managerial control ratios in research

IT managerial control ratios have been used extensively in studies attempting to link investments in IT to organizational performance as measured by various internal and market measures. Table II lists these representative studies together with their data source, employed IT managerial control ratios and measures of organizational performance.

A pioneering study by Bender on the impact of information processing expenses on organizational performance in insurance companies found that greater IT expense (measured by IT expense/operating expense ratio) was associated with higher organizational performance as measured by the ratio of total operating expense to premium income. Certain categories of IT expense (such as IT expense devoted to hardware, salaries of application developers, and computer centers) were highly correlated with organizational performance, suggesting importance of investment in these elements of IT infrastructure. The relationship between IT expense and organizational performance was found to be concave. Thus, the optimal level of IT expense/operating expense ratio was found to be in the range of 20-25 percent. In addition to providing some evidence of positive contribution of IT expense to organizational performance, this study demonstrated usefulness of IT managerial control ratios as measures of IT investment. A later study by Harris and Katz (1991) using the same source of IT expenditures data in the insurance industry found that in top performing insurance firms information technology costs as a proportion of total operating costs were higher and information technology costs as a proportion of premium income were lower.

Another early study was conducted by Weill (1992) in the valve manufacturing industry. The study found that a high degree of transactional IT investment (measured

Table I.
Numerator and denominator variables

Numerator variables	Denominator variables
Commonly used	*Commonly used*
IT expense (and its categories: hardware, software, personnel, etc.)	Revenues
IT budget (and its categories)	Operating expense
	Employees
Less commonly used	*Less commonly used*
Operating IT budget	Assets
IT stock (and its categories)	Selling, general and Administrative Expense

Study	Ratio	Data source	Organizational performance measures
Bender	IT expense/operating expense	Life Office Management Association (LOMA) information processing database (LOMA is the insurance industry trade association for life insurers)	Operating expense/premium income
Weill	IT expense/annual sales	IT investment data were obtained from 33 CFOs of valve manufacturing companies	Sales growth, return on assets (ROA) and two measures of labor productivity (the number of non-production employees per million dollars sales and the percent change in this measure)
Harris and Katz (1991)	IT expense/total expense; IT expense/premium income	Life Office Management Association (LOMA) Information Processing database (LOMA is the insurance industry trade association for life insurers)	Operating expense/premium income
Mahmood and Mann (1993)	IT budget/revenues; value of IT/revenues; IT staff budget/IT budget; IT staff training budget/IT budget; number of PCs and terminals/employees	Computerworld	Sales per employee, return on sales, sales by total assets, return on investment, market to book value
Mitra and Chaya (1996)	IT budget/sales	Computerworld	Average production costs, average total costs, and average overhead costs
Henderson *et al.*	IT expense/revenues; IT expense/book value	InformationWeek survey	Residual income, earnings volatility, stock price, long-run abnormal returns
Han and Mithas (2013)	IT expense/revenues	InformationWeek survey	Operating expense/revenues

Table II.
Use of IT managerial control rations in research

by the ratio of annual IT expense to sales) was significantly and consistently associated with strong long-term performance of companies in the industry. However, a high degree of investments in strategic IT applications was found to be neutral in the long term and associated with poor financial performance of companies in the short term. Thus, the study suggested that early adopters of strategic IT applications could achieve impressive financial results. However, once IT becomes common within an industry, opportunities for competitive advantage become limited. The study also included a number of moderating variables in the analysis of the link between IT investment and organizational performance. Conversion effectiveness, which reflects the quality of the firm-wide management and the degree of commitment to IT, was found to be a significant moderator between strategic IT investment and firm performance.

A study by Mahmood and Mann (1993) utilizing the Computerworld database of IT expenditures of "Premier 100" companies found that such organizational performance

measures such as sales by employee, return on sales, sales by total assets, return on investment, and market to book value are affected by IT budget as percentage of revenue, the percentage of IT budget spent on training of employees, number of PCs per employee, and IT value as a percentage of revenue. The growth in revenue and percentage of IT budget spent on staff were not significantly related to any of the measures and were deemed to be not useful for modeling the relationship between IT investment and organizational performance. A later study by Mitra and Chaya (1996) utilizing the same data source from the Computerworld found that higher investments in information technology were associated with lower average production costs, lower average total costs, and higher average overhead costs. Larger companies spent more on information technology as a percentage of their sales than smaller companies.

The use of IT managerial control ratios as measures of organizational IT spending continued into the new millennium. For example, a recent study by Henderson *et al.* found that IT expenditures (measured by IT expense/revenues and IT expense/book value ratios) help explain future organizational performance as reflected in both accounting measures (residual income, earnings volatility) and market measures (stock price and long-run abnormal returns). The study by Han and Mithas (2013) demonstrated that greater investment in IT (measured by IT expense to revenues ratio) improves effectiveness of IT outsourcing in reducing organizational operating expenses.

IT managerial control ratios in benchmarking

Another popular use of IT managerial control ratios is IT cost benchmarking. There are many instruments and models of benchmarking (Anand and Kodali, 2008) that are used for comparing and analyzing various aspects of the IT use within organizations (Hong *et al.*, 2010; Singh *et al.*, 2013). Yet IT managerial control ratios are commonly used in cross-sectional comparison of IT spending where an IT managerial control ratio of one organization is compared to industry averages (Computer Economics, 2013). Ratio data are collected on an annual basis by IT market research firms, such as Forrester Research, Gartner Research, InformationWeek, etc. These firms obtain the data either through self-reports from senior IT managers or by asking senior IT managers for their dollar IT expense and then using external data sources (e.g. Compustat) to obtain values for size deflators (e.g. revenue, operating expense, number of employees). The data are obtained either through random sampling across industries or by obtaining data from a preexisting set of companies known for their "best in class" IT organizations (e.g. in the case of InformationWeek 500 survey).

After ratio data are gathered, it is categorized into industry groups and, subsequently, "averages" are computed for each of the industry groups. These averages are viewed as "industry norms" (or "ratio standards"). The most commonly used averages are:

- median ratio ($\tilde{x}$) – the value of a ratio within an industry sample which splits the sample into two equally sized groups; and
- mean ratio ($\bar{x}$) – the value of a ratio obtained by calculating the mean of the ratios within a sample.

Senior IT managers compare these averages to the values of IT managerial control ratios of their IT organizations to compare it against the industry norm. Depending on an organization's position relative to the industry standard, senior IT managers may

adjust their budget levels to be closer to the industry norm (Kobelsky *et al.*, 2008), operating on the assumption that either having too high or too low ratio will attract unwelcome senior management attention.

Reliability issues

Both uses of IT managerial control ratios may be significantly impacted by the numerous reliability issues associated with these ratios. Reliability generally refers to the consistency or stability of a measure (Cozby, 2001). In the context of IT managerial control ratios, reliability can be defined as the extent to which a choice of numerator and denominator variables makes a ratio a reliable measure of organizational IT spending relative to size. Reliability problems in relation to IT managerial control rations arise from two areas: properties of numerator and denominator variables used in a particular managerial control ratios and how values of these ratios are collected from companies. These two areas of reliability problems are discussed in detail below.

Properties of numerator and denominator variables

Specific examples of reliability problems associated with some of the most commonly used numerator and denominator variables are summarized in Table III and explained in more detail further.

IT Expense may not be a reliable measure of organizational resources devoted to IT because respondents may have different interpretations as to what constitutes an IT expense. In accounting, the term expense has a very specific definition – it refers to the monetary expenditures which can be matched against revenues. Monetary expenditures which cannot be matched to revenues of the current period are capitalized (that is considered to be assets and not expenses) and are depreciated over time. Companies are not required to report their IT expense in public statements. Therefore, the value of IT expense is typically obtained by IT market research firms by surveying Chief Information Officers (CIOs) or Chief Financial Officers (CFOs). These surveys are often conducted over the phone. When asked to provide the value of IT expense, a manager may have difficulties providing a reliable estimate, since determining the value of IT expense requires a certain degree of interpretation of

	Reliability issues
Numerator variables	
IT expense	Ambiguity in defining what constitutes an IT expense
IT budget	Does not fully reflect IT cost: much IT-related costs are inquired outside of the IT department (e.g. costs related to IT-driven work disruption and end-user learning) IS organizations can be at different stages of infrastructure build-up, making the variable less useful for cross-sectional comparison
Denominator variables	
Revenues	Volatility of revenues
Employees	Sensitive to labor-capital mix: even organizations within the same industry may have a different degree of reliance on human labor Impacted by the degree to which a company uses IT to replace labor

Sources: Bartels (2007), Brynjolfsson and Hitt (1996), Gibson and Nolan (1974), Mitra and Chaya (1996)

Table III.
Reliability issues with some numerator and denominator variables

what constitutes IT expense and what does not. Moreover, a manager may overlook certain "hidden" sources of IT expense, such as depreciation of IT assets. All of this makes it difficult to obtain a reliable IT expense estimate from companies.

Compared to IT expense, IT budget is believed to be a more reliable measure of organizational financial resources devoted to IT due to the fact that this term is subject to less ambiguity in interpretation (Bartels, 2007). Still, this numerator variable suffers from two reliability problems. First of all, this number does not fully reflect total IT costs (Mitra and Chaya, 1996). Up to 30 percent of costs related to IT initiatives are believed to be outside of the IT department (e.g. expenses due to user training). Second, using total annual IT budget as the numerator variable makes cross-sectional comparison among companies problematic (Bartels, 2007), since organizations can be at different stages of IT infrastructure build-up (Gibson and Nolan, 1974). An organization with more mature IT organization may devote less money to its IT function compared to an organization with an evolving IT function. As a result of that, there will be a difference in budget levels relative to size.

Some researchers have argued that revenues is a volatile measure of organizational size (Brynjolfsson and Hitt, 1996). Their argument is that revenues tend to fluctuate from year to year – something that will result less reliable ratio data. However, it is not clear why this measure is more volatile than other measures of organizational size, such as operating expense.

Another candidate measure, number of employees, is believed to be a less volatile measure of organizational size (Brynjolfsson and Hitt, 1996). This measure makes ratios sensitive to labor-capital mix of an organization. Moreover, a high value of a ratio may reflect replacement of labor with IT (Bartels, 2007). Thus, companies appearing to be inefficient users of IT resources as shown by the ratio may be, in fact, quite successful in replacing some of their clerical tasks with cost-effective IT solutions.

Data collection method

This factor deals with the question of how easily data can be collected from companies. IT spending is regarded as confidential data by many organizations and managers are often reluctant to release this data to an outsider. Reporting a ratio as opposed to a raw spending number can make respondents more comfortable with revealing this information. At the same time, this approach to protect respondents' confidentiality creates additional problems. For many respondents, estimating ratios reliably using certain organizational size variables is more problematic, something that results in a less reliable data overall. For example, while an executive may provide a reliable estimate of the annual IT budget, reporting the IT budget as a percentage of operating expense or per employee may be problematic. If data are collected in the form of ratios, it may be advisable to use IT budget/revenues ratio. It has been argued that this ratio closely corresponds to executive economic thinking (Koch, 2006). In other words, it is easier for an executive to think about IT spending in terms of proportion of revenues rather than as a proportion of operating expense or per employee basis. Consequently, data on this ratio are easier to collect from senior IT executives than is that from other ratios, such as IT budget as a percentage of operating expense or IT budget per employee (Bartels, 2007).

Validity issues

Interpretation of an organization's position relative to an industry norm is subject to some ambiguity, as there are a number of theoretical explanations as to why a

particular organization is below or above the industry norm with respect to a particular ratio (see Table IV). Therefore, validity of a decision to increase or decrease IT spending depends on correctness of understanding as to why a particular organization is below or above the norm with respect to IT spending.

Using the general literature on IT strategy, one can come up with several reasons as to why a particular organization may have an IT spending ratio below the industry norm. The first possible interpretation could be that an organization is not spending enough on IT (underspending). This can potentially result in technological obsolescence of the organization's current IT infrastructure and lead to competitive disadvantage. In this case, the organization needs to increase its IT spending. On the other hand, it could be that an organization is below the industry norm due to superior efficiency in utilizing IT resources. This can be a result of the company being in possession of superior managerial IT skills (Mata *et al.*, 1995). Thus, below average IT spending may be accompanied by an adequate quality of IT services (DeLone and McLean, 2003). In this case, there may be no need to increase the budget. Alternatively, the position below the industry can be explained by the fact that an organization does not make a substantial use of IT in its strategy and operations. For example, the organization may be using highly personalized customer service approach as a part of its differentiation strategy (as opposed to relying on E-Commerce). In this case, increasing IT budget may not be justified. Finally, an organization may have a mature IT infrastructure. Naturally, this organization is likely to spend less on IT compared to organizations that are building up or upgrading their IT infrastructure. In this case, no adjustment to IT spending may be necessary.

Similarly, there can be several alternative explanations as to why an organization's IT spending ratio is above the industry norm. An organization can be above the industry norm with respect to IT spending if the organization's IT resources are not utilized efficiently. This can potentially lead to a case of the so-called "productivity paradox" (Roach, 1991), where increased IT spending does not result in any improvement in organizational performance. In fact, this may lead to deterioration in organizational performance as unnecessary IT spending may cut into the organization's bottom line. In this case, it may be necessary to initiate cost-cutting initiatives in relation to IT. Alternatively, an above average IT spending may be a result of an organization's heavy reliance on IT in its operations and strategy. For example, an organization may be using IT as a part of its IT-enabled strategic initiative, aimed at improving its competitive position (Piccoli and Ives, 2005). Finally, an organization may be at the stage of IT infrastructure build-up or upgrade. In this case, it is natural that the organization's IT spending is above the industry norm.

Recommendations

In the light of the reliability and validity issues associated with using IT managerial control ratios of benchmarking IT costs, several recommendations can be made to

Below the norm	Above the norm
Underspending on IT	Overspending on IT
High efficiency in utilizing IT assets	High reliance on IT in operations or strategy
Low reliance on IT in operations or strategy	IT infrastructure build-up or upgrade
Mature IT infrastructure	

Table IV. Alternative theoretical explanations of a position relative to an industry norm

market research firms as well as companies using their data for IT cost benchmarking. Since values of IT spending are self-reported by companies (in other words, public companies are not formally required to report and audit their IT spending data), it is advisable to use total annual IT budget as a measure of organizational IT spending. In comparison to such measure as IT expense, the concept of IT budget is less ambiguous. Thus, a somewhat reliable estimate of IT budget can be obtained from a senior technology leader or a CFO. Second, it is advisable to use a number of employees as a denominator. This measure of organizational size is believed to be less volatile in comparison to such size deflators as revenues or various categories of organizational expenses (Brynjolfsson and Hitt, 1996). The number of employees can be obtained from publicly available sources (e.g. Compustat database). The value or IT budget per employee is likely to be a more reliable estimate of IT spending for both researchers and practitioners.

If the absolute value of the IT budget cannot be obtained (e.g. due to confidentiality concerns among companies), the ratio of IT budget to revenues should be obtained from senior technology leaders. First, it has been argued that this ratio closely corresponds to executive economic thinking (Koch, 2006). In other words, it is easier for an executive to think about IT spending in terms of proportion of revenues rather than as a proportion of operating expense or per employee basis. Consequently, data on this ratio are easier to collect from senior IT executives than that from other ratios, such as IT budget as a percentage of operating expense or IT budget per employee (Bartels, 2007).

Having obtained a company's position relative to the industry mean, both researchers and practitioners should be careful in how they interpret this fact. As it was discussed in this paper, a position below or above the industry norm is subject to several alternative interpretations and some of these interpretations are quire orthogonal. A position below the industry norm can be a result of underspending on IT, high efficiency in utilizing IT assets, low reliance on IT in operations or strategy, or mature IT infrastructure. Similarly, a position above the industry norm can be a result of overspending on IT, high reliance on IT in operations or strategy, or IT infrastructure build-up. Given this ambiguity in interpreting a company's position relative to the industry "norm," the results of benchmarking should only be used as a starting point for further research and discussions regarding the appropriateness of the level of IT spending within an organization. Researchers should include control variables that would rule out alternative interpretations of values of these ratios.

Directions for future research

Of course, the main limitation of this paper is that it does not confirm the existence of the reliability and validity issues in relation to IT managerial control ratios. Thus, researchers should examine whether reliability problems associated with IT managerial control ratios can lead to sub-optimal decisions with respect to capital allocation to IT. Also, it would be interesting to investigate how practitioners interpret values of IT managerial control ratios and whether alternative interpretations can influence their decisions. In the context of IS studies linking IT spending (as measures by IT managerial control ratios) to various measures of organizational performance, it would be beneficial to revisit the studies that did not find a significant relationship between IT and organizational performance and determine whether the reliability problems were to blame. Also, it would be

interesting to see whether alternative theoretical interpretations of what these ratios represent can bring alternative interpretations or new insights into the findings of published studies on IT payoff.

Conclusion

IT managerial control ratios are at the heart of the practice of IT cost benchmarking and form the foundation of IS studies, linking values of these ratios to various measures of organizational performance. The reasons behind the popularity of these ratios in benchmarking and research are rather pragmatic. The problem is that managers often do not have enough time for a more rigorous analysis of their IT spending data using more formal and robust evaluation techniques, such as ROI, NPV, balances scorecards, or real options analysis. Similarly, researchers often do not have the resources to collect granular data on IT spending from companies and have to rely on existing industry samples of IT managerial control ratios that were collected by market research firms for the purposes of benchmarking. These important uses of IT managerial control ratios should not be carried out without understanding the reliability and validity issues discussed in this paper.

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