TOTAL COST OF IT OWNERSHIP AND USAGE: REVIEW AND EXTENSIONS

D.H. DRURY

McGILL UNIVERSITY, MONTREAL, CANADA

Abstract

The power of information technology to reshape economic activity continues unabated. Rapid change and rising costs have been mainstays of the Information Technology revolution. The emerging reality to organizations is that Information Technology must be used effectively. Concerns have been raised over IT effectiveness measurement, cost justification, and cost containment. Throughout the 1990's, these problems have highly ranked among the key IT issues in studies conducted around the world.

All resources need to be managed to realize opportunities. Isolating the benefits of Information Technology and relating them to the associated costs has proved elusive and threatened emerging opportunities. A change of approach has been advocated to overcome these problems which focuses on the Total Cost of Ownership. Over the past several years, the Total Cost of Ownership has been both hailed and scorned.

The origins of the Total Cost of Ownership and its development provide the foundation for inquiry. The advantages and disadvantages of this cost measure are discussed from the extant management literature. Current usage of the Total Cost of Ownership is examined. Considerations of capacity levels, opportunity costs, and positive and negative externalities are introduced to focus on cost containment issues. The assessment identifies the pitfalls and opportunities in using the Total Cost of Ownership to ascertain the costs of Information Technology.

1. Introduction

Continual change and rising costs have been mainstays of the Information Technology revolution [8]. The pace of new developments seems to be limited only by the imagination. The reality to organizations is that Information Technology must be used effectively. Concerns have been raised over IT effectiveness measurement, cost justification, and cost containment. Throughout the 1990's these latter problems have ranked among some of the top key IT issues in studies conducted around the world [17][49][55][62]. The benefits and costs of IT have been major concerns since the earliest computer applications with little progress being made [44][65].

There is ample evidence that IT cost determination and evaluation are universal and critical management problems. According to a survey by the Executive Insight Group, CIO's are feeling widespread dissatisfaction with evaluating, monitoring, and managing IT costs. More than 2/3 of the executives surveyed expressed dismay over their companies IT cost justification system[10]. It has been estimated that less than 1/5 of all corporations have a process in place by which to cost justify IT [60]. A study by Grant Thornton Inc. shows that only about 15/% of manufacturing executives try to measure the return on investment of their Information Technology. Less than 1/3 track the cost performance of IT projects. Comdesco, an asset management service organization found that only 12% of U.S. companies track the cost of distributed computers. Only 43% of U.S. companies have an IT asset management plan in place [49]. In another survey in London, seventy-one percent of IT managers could not say whether their IT is delivering value for money, yet spending on hardware and software accounts for up to a quarter of total business costs at many firms [26]. Only 38% of top management's in textile companies believe their IT systems to be cost-effectively developed to maintain a competitive advantage or at least meet basic needs [35]. Obtaining IT value and controlling costs have proved to be elusive for organizations.

IT investments should boost national productivity, corporate profits and standards of living. What puzzles economists is that productivity growth measured in the seven richest nations has instead fallen precipitously in the past 30 years, from an average of 4.5 percent a year during the 1960's to a rate of 1.5 percent in recent years. The closedown has hit the biggest IT spenders, service sector industries, especially in the U.S. the hardest. Most of the economic growth of the 1990s can be explained by increased employment, trade, and production capacity. Computer contributions, in contrast, nearly vanish.

In an effort to explain this paradoxical result, much of the early work on IT cost/benefit comparisons moved from the macro-economic effects to focus on the firm as the unit of analysis [3]. However, the relationship between IT costs, productivity, and profitability at this level has been found to be tenuous and inconsistent [4][47]. Recently, there has been a growing recognition that IT impact can be identified through intermediate level contributions [41]. Some recent studies have taken a process orientation to measure IT business value. For example, Banker, Kauffman and Morey [1] examined the impact of new cash register and order coordination technology in fast-food restaurants. Barua, Kriebel and Mukophadhyay [2] used a two-stage model to measure the contribution of IT in different functional areas (production, marketing and innovation). Dewan, et al., used a production function to model the relationship between the inputs and outputs of the trade services process [18].

The difficulties in specifying cost/benefit relationships have consistently been related to measurement of benefits. In retrospect however, the importance of measuring IT costs were under emphasized. This became apparent when the unit of analysis became further reduced from determining the total impact of organizational IT costs, or individual systems, to the focus on a more basic unit of analysis. The proliferation of desktop equipment and the growing importance of the individual user became the target of fundamental cost determination in the middle 1990's. This has been labeled the Total Cost of Ownership (TCO) which is an attempt to obtain a more accurate measure of IT costs that could then be added to obtain the total IT cost, and therefore, be related to the impact on the organization. Ideally, the identification of cost effectiveness and efficiency at the level of basic elements would be expected to enhance resource allocation, performance evaluation, and align IT spending with organizational goals.

Perceptions of price/performance continue to slip and IT spending continues to rise [59]. Companies are spending a lot of money on expensive technology and increasingly, IT departments and are finding that they have to demonstrate their worth. This results in an increasing emphasis on metrics in order to support IT in the corporate environment. For these reasons, TCO seemed to be a natural extension to the reductionist process in determining IT costs. Some believe that this metric is beneficial in addressing management cost concerns. It is the fundamental building block from which subsequent cost and benefit issues would be addressed. However, others writers dismiss TCO as incomplete, misdirected and irrelevant. Proponents for and against have maintained strong views with little attempt at reconciliation and advancement. Yet, the TCO debate in the management literature is important since it questions the limits on the measurement of IT costs and therefore, the structure of cost/benefit analysis in the context of Information Technology.

Widely accepted alternatives to TCO have not emerged. It may be better to use the metrics available if the limitations are isolated and articulated. Further, the identification of problems may lead to solutions that overcome objections to measurements of basic elements of Information Technology. On the other hand, practices that are misleading and have limited potential for improvement deserve to abandoned. The objective of this investigation is to examine the divergent viewpoints of TCO debate and derive conclusions. It is necessary to investigate what TCO means, where it originated, and its intended purpose to make this assessment. This leads to examining the arguments that have been expounded for and against TCO and the evidence of its usage in practice. The conditions for usage and complications that need to be addressed are isolated which place the TCO debate appropriately the context of IT research and practice literature.

2. Background

Since humans began organized trade, people have realized that the purchase price of an item is not the only cost involved in buying a product and may not even be the largest cost. For many years, purchasing agents have been aware of the importance of considering "all-in-cost", "life cycle costs", or total cost of ownership" [20]. Briefly, the concept of total cost of ownership is that an organization must consider all the costs related to a purchasing decision, including purchasing installing, running, maintaining, repairing, overhauling, and disposing of the product [5].

While Total Cost of Ownership is a new term, the underlying paradigm is over fifty years old [34]. The classical life cycle curve is roughly a bell shaped curve with a mathematical description of $y = \alpha + \beta X + CX^2$. The importance of product life cycle is that it defines the useful life of a product. As new products are introduced, older products become obsolete requiring replacement, maintenance and support increase, and comparative efficiency decreases. Thus, the cycle of introduction of new products affects the internal life cycle of the product to user organizations. Total Cost of Ownership captures the total changing costs of products in use over their lifetime.

TCO has been receiving a lot of attention lately. According to a recent survey, eight in ten purchasing executives try to base their decisions on TCO [56]. TCO has even found applications in government. The Department of Defense issued a memorandum directed at reducing TCO which it defines as the sum of all financial resources necessary to

organize, equip, train, sustain, and operate military forces sufficient to meet nation goals in compliance with all laws [16]. Articles have appeared about the Total Cost of Ownership in areas as diverse as high volume copiers [61], office desks [57], and cars [23]. However, the place where TCO has received the most attention recently has been in the field of computing.

The Total Cost of Ownership attempts to quantify the actual amount of money a company spends for a personal desktop computer including purchase price, cost of deployment, maintenance, and support over its useful life to the organization. In the last twenty years, business computing has moved from a centralized system run by information systems professionals to a decentralized model, with computers on every desktop. The central idea is that analysis of and all the costs of the life cycle (introduction to disposal) results in more informed business decisions and behaviors. Although TCO factors vary according to technology and environment, costs are typically broken down into categories such as capital costs, technical support, administration, and end user operations.

3. Advantages and disadvantages of TCO

On the surface, TCO has an inherent simplicity and basic logic. First, increasingly organizations in the 1990's have sought to more accurately determine the full costs. Approaches that simplistically allocated costs to products have given way to efforts to finely classifying costs in alternative ways and determine cost drivers that more accurately measure resource utilization and commitment. Whether the product is a computer, passenger on an airline, or a patient in a hospital, more accurate measurement of cost objects continues to be an overriding concern of organizations in seeking competitive advantage [11]. The culture is to more accurately measure the cost of basic cost objects and the desktop computer is a natural extension of this trend.

Second, while there are some variations in the cost of desktop systems depending on where and how they are bought, the basic components are not only well known but also widely advertised. They are essentially the same as the equipment at home as in the office, doing essentially the same thing. The basic technology and options are seemingly well known. Since its inception in the early 1980's, successive generations of PC's have been replaced together with applications and operating systems. This is a technology that is familiar, not obscure.

Third, if the cost of one desktop is known, then if follows that the cost of all desktops can be determined thus reconciling to the total costs to the entire organization. These costs can then be used to make comparative measurements and gauge progress in directing the IT strategy of the organization.

The management literature cites additional advantages of TCO. Literature and internet searches reveal other reasons for positive support. These are summarized in Table 1.

Table 1 Advantages of Total Cost of Ownership

Provides justification for decisions	Nelson [51]
Supports outsourcing	Mould [48]
Emphasizes cost avoidance	Essex [25]
Avoids the easy way out	Hudgins-Bonafield [37]
Prepares for life cycle changes	Gale [29]
Forces cost savings	Carr [7]
Forces identification of tracking of information technology assets	Wheatly [64]

By incorporating cost of ownership analyses, companies are in a better position to decide which suppliers offer the best overall value. Traditional accounting systems favor the lowest price supplier to avoid unfavorable purchase variances but the does not reflect the true total cost of ownership. The improvements generated by cost of ownership systems are due in large part to improved communications between buyers and sellers that the systems foster. The true value in cost of ownership measurement is thought to lie in helping suppliers reach their full potential in the partnership between buyers and their suppliers rather than serving as a club for extracting concessions.

Essex believes that TCO supports outsourcing decisions as part of IT operations such as Web applications to total seat management. It contains procurement, asset management, user training and servicing. The number of help desk calls are reduced and customer satisfaction is increased. TCO to be only part of a much wider asset management plan for asset management. Envisaged are effects that combine clipboard and pencil inventories with dedicated asset repository, automatic discovery of assets on the network, and rework software installation. They also employ work

tools that inform help desks and server managers which assets they support and which ones are breaking down. The cost of asset management efforts themselves will be hard to quantify without financial tools that bring the total cost picture clearer into focus. The focus is directed to cost avoidance rather than current cost reduction. To Carr, TCO forces cost savings at all stages beyond procurement. Hudgins-Bonafield sees other reasons for TCO. She believes that it is easier to sell IT to senior management based only on purchase prices. The larger numbers of TCO include all costs generating more realistic initial assessments and avoiding surprises and frustrations later on.

Information Technology vendors continually narrow the window between a new product and the arrival of its technological replacement in order to stay competitive. TOC emphasizes the importance of efforts in the early part of the cycle to avoid costs since many costs are locked in once the technology is acquired. Further, Gale suggests that life cycle thinking includes preparing for the next cycle and making plans for the transitions which become cost/benefit efficient.

In spite of seemingly convincing arguments for TCO, recently the disadvantages have become more defined. The following concerns in Table 2 have been expressed in the literature.

Table 2 Disadvantages of Total Cost of Ownership

Costs not comprehensive	Dempsey [15]
Not sophisticated	Liebman [42]
Negative performance effects	Kaplan [39]
Does not consider value	Gillooly [22]
Ignores productivity gains	Dugan [22]
Shortsighted in perspective	Hurwitz [36]
Difficult to accurately calculate and spread overhead costs	Milligan [46]
Lack of industry standard for measurement	Weinberg [62]
Fantasy document	Greenbaum [32]

In spite of the objective of including all costs, some writers feel that TCO leaves out some costs such as complexity. Complexity costs which are among the most important and frequently neglected costs associated with IT investments. They include the ongoing increases in operating costs that arise when a company supports multiple technologies and standards. They also leave out transition costs or the one-time costs associated by the move to the new system. They may be incurred if business is interrupted or stopgap IT solutions are required.

Liebman believes that TCO offers only a primitive view of technology spending and needs to be replaced by more sophisticated IT financial metrics. Underlying most TCO discussions is the idea that lower TCO is good. Liebman considers this to be naive as (1) the sophistication of an organizations IT depends on its business and (2) reducing IT costs does not necessarily increase return on investment. A recent survey of 250 IT managers revealed that, while 80% claimed to be doing comprehensive asset management, only 75% actually did even the most basic physical inventory of assets. And only 10-15% of the total respondents were tracking rudimentary financial data about IT assets, such as lease payments and depreciation. The idea of capturing life-cycle activity costs ie. the support and maintenance costs, for many organizations may be far from reality.

The emphasis in TCO is viewed as cost cutting. The assumption is that organizations can improve operations by lowering their TCO. Kaplan considers this to be a dangerous premise for many organizations that are already underfunding their IT operations and need to make greater improvement. Focusing on the cost side of the equation places greater pressure on staff and ignores the negative impact cost cutting can have on IT performance and end user satisfaction. Instead, he argues that TCO should not be used but the focus should be on ROI. ROI is though to identify the positive impact of IT initiatives are aligned with the overall businesses of their company. This approach is thought to ensure that efforts are aligned with the overall business of their company, and an ROI based management strategy can prove the economic value of IT with business units.

Further, because TCO emphasizes costs it is viewed as a temporary solution to IT evaluation. While lowering TCO is important, it is a negative maintenance policy. Monitoring and managing costs are important, but these can be a crutch for executives who lack vision for more positive activities. Whether TCO directly adds sales value, increases market share, or provides lasting competitive advantage is questioned. Milligan cites the considerable difficulties in cost allocation to obtain accurate costs of TCO questioning the accuracy the final numbers and Greenberg that TCO is more of a fantasy document than reality. Further, there is no industry standard to compare TCO costs and calculations with other organizations. The basis for improvement or external validity of processes and amounts is absent.

The reasons for advocating or rejecting TCO are both compelling. On the one side, the advantages seem to lead in directions which overcome many of the difficulties which organizations experience in controlling burgeoning IT costs. On the other side, the disadvantages also seem to have considerable merit in missed objectives and technical problems. The experiences of organizations are revealing in projecting the future outcome.

4. Current usage

Organizations have not been quick to adopt TCO in Information Technology management. Businesses currently put a premium on buying applications that are integrated with their existing desktop applications and network operations rather than on TCO. In a survey by Information Week Research, 56% of the respondents said the most important reason was integration and only 8% said their first priority was to cover TCO [37]. IT managers seem to be aware that the annual cost of administering a PC can exceed its purchase price, but the total cost of ownership is not a major factor in purchasing decisions [45]. According to a survey by Forrester Research, 78% of all IT administrators don't track TCO costs [24]. The Gartner Group, a leading research firm, started a consulting group dedicated to issues surrounding TCO. They also introduced TCO Manager, a tool designed to help managers conduct TCO analysis including a database for 250 companies, quarterly update, and training [30]. However, due to lack of interest, this program was abandoned. Companies interviewed by Computer World found that they didn't think in terms of TCO terms and say that they have no idea what their TCO per user is. Although they don't emphasize their TCO, they control costs in other ways including (1) standardization of software and systems first tracking the short menu of standard items and a slow rigorous approach to non-standard items, (2) remote desktop management, (3) lease rather than buy, (4) standardization of equipment which brings volume discounts, (5) limiting software that users can add to their PC, (6) thin client implementations, and (7) tools that track hardware and software [21].

While companies have avoided the concept, product designers have not. Recently, many articles have appeared arguing whether one particular computer structure [14], or operating system [58], has a lower total lifetime cost. Software and microprocessor producers are aware that the public is paying attention to the costs of owning and using a product, and are making moves designed to reduce these costs for the user [28][38]. Many products are advertised which take account of TCO such as Winchester drives [43]. Advertisers, have been quick to pick up on the advantages emphasized in TCO. The reason is that the purchase cost is not a major cost for some IT components. The purchase price of a printer for example, is only about 5% of the total cost of ownership over its lifetime [54]. However, while producers calculate what hardware and servicing costs should be over the lifetime of IT, many costs are organizational specific. Further, little of the information actually reported about TOC goes beyond general statements which make their internal usefulness severely limited. There appears to be no advantage to using base figures from advertisers of IT products without independent confirmation.

Confirmation requires that organizations have adopted the TCO approach. A reason may be that TCO has simply been slow to be adopted. Administrative innovations are new management techniques and practices. Unlike product, and process innovations, the competitive or cost advantage is not easily obtained. Also, administrative innovations tend to change internal power status, systems and relational structures in organizations. For these reasons, they tend to be resisted. Costing innovations seem to be particularly prone to these problems. Experiences with Just-in-time costing, Activity Based Costing, Kaizen costing have pointed out that many organizations have not adopted these newer techniques, in spite of wide-spread knowledge of their existence, procedures, and advantages. Thus, organizations may simply be experiencing the wait-and-see phenomenon typical of other administrative innovations.

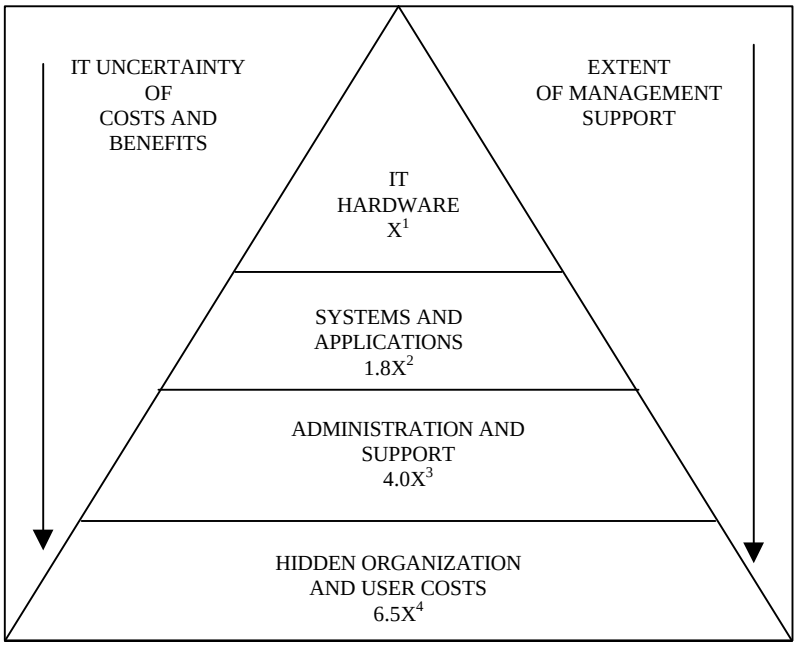
Another possibility is that the rapid change of IT has focused attention on other issues. Strategy, competitive advantages, and alignment of IT with organization priorities have become critical organizational issues. Alignment of IT has been a top priority to most organizations through he last half of the 1990's. Surveys of management issues include such issues as network management, the Y2K problem, and telecommunication [50]. Costing issues are not included in the top ten which is a strong indicator that the timing of adoption of TCO may have been appropriate.

The third reason may be technical. TCO may be impossible or too costly to actually implement. What on the surface may be a good idea, at closer inspection may be fraught with implementation and technical difficulties rendering TCO impractical to adopt. The current literature provides some insights into the nature of these issues that are extended to the costing issues involved.

5. Cost structure

Cost identification and measurement are the focus of Total Cost of Ownership. The categories of the IT cost structure can be visualized in Figure 1. The central pyramid represents the total cost of ownership for a desktop computer in an organization. The major cost categories typically used are (1) hardware costs, (2) systems and applications, (3) administrative support and finally, (4) the hidden costs. Estimates of costs indicate that starting with hardware costs, systems and applications cost add .8 or 1.8 times the cost of hardware. Administration and support increase the costs 4.0 times hardware costs and with the hidden costs, 6.5 times.

Figure 1 IT cost, uncertainty, and management support



Sources: 1- Extents Information Services; 2 - Forrester Research;3 - Zona Research; 4- Gartner Group.

Hardware costs, and to lesser extent, software and systems are both identifiable and traceable to users. In contrast, the larger portions of the IT cost structure, administration, support, and particularly the associated IT hidden costs, are more difficult to identify and evaluate. Technical support, end user operations, and administration can end up accounting for 85% of the cost of newer systems such as client/server. Technical support is where these costs can really increase, and it is this cost category which is often underestimated. According to SBT Accounting Systems in California in a 6000 person survey of office workers, one-fifth of wasted time was waiting for help to arrive. SBT estimates that this costs businesses in the order of $100 billion a year in lost productivity. Margaret Hurley estimates that non-technical employees take 4 to 10 percent of their time to help co-workers solve problems. Her estimates increase costs by including these hidden costs by 44% [13].

The most difficult Information Technology costs are those that are not even recorded. The hidden costs include training, increased development demands, system and application maintenance, and system planning. Downtime is also very expensive and typically, the cost is not even recorded. According to a Gallup survey of top 1000 firms in the country the average corporate LAN goes down 27 times per year costing its owners $35 million in lost productivity [27][6].

Another hidden cost is the “futz factor”. The “futz factor” is the amount of time employees waste perfecting their work or fixing gnawing problems [21]. A consulting report estimates that business PC users waste 5.1 hours each week futzing with their computers, learning how to use them to do things, checking the things they do and so on. Futzing is estimated to cost businesses nearly $100 billion per year [41].

As shown by the arrow down the left side, both the benefits and the costs of IT become more uncertain. At the same time, the extent of management support for IT decreases down the right side. The first implication is that the appropriate amount of spending on IT is difficult to attain. Underfunding is more likely when costs and benefits are

not easily obtained. Management's can be easily misled into acquiring hardware and systems but provide insufficient funding in the other categories to make the acquisitions successful.

Second, Figure 1 indicates that IT has a unique cost structure. Whereas labor costs have generally decreased and capital costs increased, IT exhibits the opposite behavior. While hardware costs have been decreasing, labor costs have escalated. The Gartner Group estimated that labor accounts for 70% of the total IT cost in a large enterprise. The principal classes were end user labor (41%), end user support labor (15%), application and development labor (8%), server operations labor (8%) and training (5%). These burgeoning labor costs are more difficult to handle, require much more accounting and are not easily captured. The result is that organizations tend to emphasize hardware, systems and software spending but underestimate other IT costs [60].

TCO has other properties which are more closely observed by examining the cost process. A generic cost containment process identifies cost objects, total costs, and traces and allocates costs to cost objects. Table 3 contains eight boxes in sequence partially based on the theoretical cost structure for Activity Based Costing developed by Noreen [52]. The first cell of each box lists the steps and the second provides a brief description. The third box assesses TCO against the process structure and provides recommendations for improvement.

Table 3 TCO and the Cost Process

1. Cost objects are mutually exclusive and have at least one common property.
Cost objects are organizational elements such a products, customer, department, or process. The principal reasons for isolation of cost objects are planning, control, and decisionmaking.
Information Technology cost objects are systems, projects, user departments, platforms, equipment. The cost object of TCO in this paper was the desktop computer. The desktop computer is used for multiple functions including information collection, processing , and storage The user performs many different functions including information search, analysis, and communication. The desktop computer is a poor proxy for the desired cost object

2. Total costs are identifiable.
All costs are recorded. The subset of all costs related to the identified cost object are separable.
The information technology costs for TCO have been classified as hardware, systems, administration and support and end-user costs. At least one recorded cost classification must map the subset of costs to Information Technology cost objects. For TCO, many of the costs are classified as non-IT, buried in department budgets, or completely hidden. Adding cost classifications produced fuzzy totals of Information Technology costs. Two alternative approaches are possible. Only consider acceptable costs in total costs or use the re-engineering method of reducing the set of total organizational costs to define the remaining sub-set of costs .

3. Directly traceable costs dominate.
The process of cost identification uses procedures that are traced directly to the cost object. Higher proportions of traceable costs increase accuracy of cost identification. For a typical product for example, directly traceable costs include materials which account for 60% and labor 10%. The increase in accuracy of cost containment then depends upon procedures to proxy tracing methods such as ABC that are intended to raise the level.
The proportion of directly traceable IT costs decreases as the number elements in the cost object increases. The desktop cost object has a minor component of directly traceable costs indicating that the elements were too fine to achieve the level of accuracy acceptable by users of the cost information.

4. Partitioning of costs into pools is unique.
Every cost is the product of a price and quantity which could be regarded as an activity. The art of cost identification is choosing a set of activities that proxy for a wide range of activities carried out in the organization. A measure is a satisfactory proxy if it is highly correlated with the activity.
The cost pools used for TCO were based on a mixed functional/capital classification. The extensive indirect and common costs involved in IT applications require an activity classification of the cost pools. Further, the number of cost pools was never demonstrated to be appropriate. Neither has the correspondence between the selected activities and the total set of activities and behaviors been substantiated.

5. Cost pools are proportional to the level of activity.
This rules out the level of the cost pool non-linear functions and cost functions which there are non-linear intercepts. Costs which are not strictly variable at the level of the cost pool should be excluded from the allocations and handled in some other manner.
Evidence suggests that many IT costs are linear which is positive finding costing [9]. However, the intercepts are likely to be high since information infrastructure is required even at the lowest level of activity. In other words. The TCO approach allocated all costs, usually by simply dividing the cost pools by the number of desktop computers. The required analyses instead should identify the form of the cost function for each of the cost pools separately, demonstrate the absence of cross-elasticity, and discard homogeneity..

6. Activities are partitioned into elements that solely depend on the cost object
Activity measures can be summed to arrive at total activity costs. This rules out joint processes since the demands on resources are determined by the maximum of the demands placed and not their sum . This also rules out more subtle dependencies such as congestion when overall volumes fall.
The TCO approach assumed that excess IT capacity exists. TCO requires isolating the cost of excess capacity separately and identifying constraints. Further, activities vary for the same cost object, the dependence on cost objects requiring an additional metric which weights the dependence.

7. Cycle independence of cost objects
In addition to the above properties, life cycle require inclusion of the time component. The object must have a beginning and end. Shorter life cycles mix current cost objects with new cost objects. Longer life cycles increase the uncertainty of costs in specific time frames.
Information Technology cycles overlap. New generations emerge which do not immediately replace prior technology. The cost of IT is dependent upon deviations from the optimum point in the life cycle for adoption. Costs depend on the learning curve over successive cycles. TCO depends upon the point in the cycle and is therefore time dependent. Tracking of prior generations of cost categories and using the experience to estimate future TCO costs is required.

8. Cost of objects are avoidable
Costs for decisions represent avoidable costs and rates incremental costs of activities. Avoidable costs are the change in total cost if one of the cost objects is changed leaving other objects constant.
The implicit assumption of TCO is that it is useful for decisionmaking and especially cost cutting. However, the metric failed to recognize the differences in costs and activities which could be reduced and those that could not. At this level, the choice depends upon those activities which management and users regard as essential.

6. Conclusions

The descriptive analyses of Table 3 demonstrate that the calculation of TCO did not conform to a logical costing process. TCO did not provide a level of accuracy for actual costs which subsequently led to lack of confidence and usefulness of the measure. The costing of IT must include more advanced concepts of overlapping life cycles, congestion effects, and cross-elasticities. TCO was built on analogous premises to other cost contexts. The unique structure of IT costs in Figure 1 was ignored. This is particularly apparent in the lack of cost drivers that address the significant labor costs of IT. The overcome these difficulties, organizations need to expand their collection of operating, performance, and usage data of a financial and non-financial nature. Primary and secondary measures need to be identified together with key success factors. Further, the stages of costing need to be built based on analyses rather than conjecture.

It is evident that the cost object, a desktop computer, was a poor proxy for what organizations expected. The level of specificity was too great considering that the essence of IT and its value is derived from integration. This suggests that the object of analyses should be joint, and not separable effects. Costs which are evaluated in their portfolio effects lead to assessments of effectiveness and efficiency. The lesson of TCO is that it attempted to exceed the limits of practicality and ignored the benefit structure inherent to integration..

From Tables 1 and 2, the disadvantages of TCO have outweighed the advantages at this time. It is evident that TCO has not received widespread acceptance and the reasons at this stage should be apparent. However, TCO will not disappear from the management scene but continue to be used but in a reduced form. The notion of measuring IT costs to organizations based on a specific, non-uniform computing resource was too adventurous. While narrowing the concept to equipment costs of specific computer resources presents its own challenges, TCO provides opportunities for comparisons between alternatives at this level. However, at a minimum this requires post-audit evaluations to substantiate and improve the cost process for this specific objective.

Although TCO can be viewed as another management fad, that fact that the problems are not resolved is an indicator of the state of IT costing. Organizations continue to emphasize competitive advantage, resolving operating problems, and adopting the latest information technology. Costing is given a low priority in the context. One of the most misunderstood aspects of managing information technology is the attendant economics. The rate of technical advancement is accelerating, demand is intensifying, standards and architectures are changing daily, prices are falling, but total costs are growing. Yet the legacy-based fiscal thinking of both technologists and financial officers has changed little in the face of these new realities. Understanding the attendant economics of information technology is a necessary first step toward developing sound financial strategies to accommodate technological advancement.

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