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Total Cost Ownership for Information Technology

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With the revolution in information technology assets over the past 2 decades, organizations have been increasingly concerned with the total costs of ownership of these assets. Organizations are concerned as to whether these large investments in information technology have produced as measured by bottom-line results. As more organizational resources become devoted to information technology, the answers to these questions increase in importance. Total cost of ownership is comprised of many items, including direct costs for hardware and software, along with support personnel. The direct costs must include not only desktop hardware and software but also the total environment with network infrastructure. Indirect costs are comprised of end-user issues in learning the hardware and software, technical problem-solving, and costs that can be difficult though important to measure. Facilities also play a significant role in that they must have the capability to support these information technology assets.

MEASURE COSTS AND RETURNS EFFECTIVELY

Organizations have increasingly become concerned over the past decade with the cost of information technology assets. Many firms feel that despite increased expenditures for information technology, productivity returns have been anemic or lacking altogether [5]. In certain respects, productivity measurements themselves may be at fault. An example of productivity obfuscation with information technology would be the trucking industry. The advent of logistics software means that the most economical routes can be readily calculated for all of the individual trucks in a trucking firm's fleet. This level of detail was not achieved before sophisticated logistics software because the task would have been cost prohibitive manually. The end result of the logistics software is that trucks travel fewer miles than before. Inaccurate productivity statistics in this respect can mean that the logistics software due to its effectiveness has reduced miles traveled; if this is the measure, then the trucking firm has witnessed a productivity decline.

The same example with maintenance management software could be applied to a manufacturing facility. Through the maintenance software, maintenance items are more readily flagged for repairs. This may mean an increase in maintenance labor hours to handle the increased workload or overtime. In an output/input measure of just labor hours expended, maintenance productivity declines in this case, but fewer spare parts are used with lower capital costs. If management just examines the labor hours side of the equation, the net apparent effect of the maintenance management software has been of no value. Information technology has only added costs to the maintenance equation on a cursory basis, if labor hours are the only criterion.

Another example is with a computer-controlled machining station for a firm constructing themed solutions for clients ranging from corporate events to theatrical productions and fixed building installations. Before, craft personnel cutting patterns out of wood would spend hours on this task; now, computer-aided design can be networked directly to this machining station. The station cost $400,000 and has enabled the firm to do more work, but they have lowered their prices to clients to be more competitive. Thus a job that before the machining station cost X now costs X-1. If output is measured in dollars, it might appear that productivity has gone down. Yet the firm is more competitive than ever due to this enhanced information technology.

It also should be noted that often information technology is a defensive investment. These are expenditures that have to be made if the firm is to stay competitive. The only other alternative besides the dictate to automate is to evaporate. The question in this case is to spend these information technology dollars in the most effective manner. Changing from a PC-centric computing model to servers with network computers may save an organization 25 percent of its costs [1].

The other aspect of information technology investments is that it should enable better decision-making due to more timely information. Decisions should be of a higher caliber and there should be quality improvement. Productivity just measures output, however. It is somewhat reminiscent of the chandelier factory in the former Soviet Union where bonuses were given for production based upon the total weights of chandeliers produced in a year. After a period of time, chandeliers produced were so heavy that they were pulling down the ceilings in newly-constructed buildings. Productivity measures are often inaccurate because of their simplistic approach.

SELECTING ADEQUATE TECHNOLOGY LEVELS

The first responses of some organizations concerning information technology is to scale back or reduce costs for physical hardware. One current thought in this area is "since this technology is outdating itself so fast anyway, let's not purchase state-of-the-

art equipment since we'll dispose of it in 3 years anyway." The problem with buying at the low-end hardware price point is that low-end technology has already been obsolete for 2 years or so. If the replacement cycle is then 3 or 4 years, people may be frustrated by the hardware performance. The machines of today, aside from the latest advanced processors, don't find a significant amount of price differential in processor speed/capability anyway. Instead, the various price points are more heavily based on peripherals such as hard drives and monitors.

My bias, as an example, is to buy the largest monitors one can afford because they have a key effect on personnel productivity. Larger monitors are essential for end-users concerned with computer-aided design (CAD) applications. A receptionist who only occasionally performs light word processing will not need a larger monitor. The same principle applies to selecting machines of a certain capability. A CAD designer may require the most advanced machine due to the power-hungry nature of these applications. However, equipping the receptionist with a power machine is similar to using a chainsaw to sharpen pencils. The same would apply to color printing technology. Everyone does not need a color printer on their desktop. The hardware costs of the printer can be minimal, but supply costs for paper and ink can be expensive. Vendors selling printers are analogous to razor manufacturers. The printer unit is essentially sold at a very low margin to create demand for higher margin consumables. Again, printer sharing in the case of color printers can provide an adequate level of technology. Equipment should fit the application. This may mean something as basic as selecting two types of configurations: an entry-level model and a power-user model. Although some may bristle at the tag "entry-level," and egos get in the way. In some organizations, this means that those most politically powerful but least in need of high-end PC processing requirements actually end up with power-user models.

Software is another key area of concern. An organization such as a contractor performing small or mid-size projects under $50 million may not require a high-end software scheduling package. It may be able to achieve scheduling and project control requirements with a lesser package that costs a tenth of the high-end package. Multiplied out over a large number of projects and end-users, these savings can be substantial.

The other issue with selecting adequate technological levels is predicting the use of the technology over its life cycle. The simple PC purchased today for light word processing may be tasked next year with processor-intensive database retrieval work. The issue of standardization covered below may mediate a higher level of information technology capital costs than is immediately apparent.

TOTAL COST OWNERSHIP

One problem with the total cost ownership (TCO) concept is that some organizations have focused the issues too narrowly on just one item, namely desktop hardware. However, while desktop hardware costs are relatively easy to measure, this is not where the real costs reside.

The desktop hardware part of the equation is particularly baffling to many managers because the personal computer since its inception has seen continually dropping prices. Those first starting with PCs in the early 1980s can remember when an extra floppy disk drive option cost an additional $1,000. Today that same $1,000 buys an entire budget machine. Given these trends of continually dropping prices and continually increased machine power, why don't these trends show up in net benefits to the corporation?

Many cost models are rooted in traditional cost models used in other facets of the organization. These cost models center on physical assets. The construction equipment owned by a contractor can be accurately costed by adding up the prices of the individual physical assets.

Information technology is a different kind of animal when developing cost calculations. Fixed asset measures such as return on investment don't begin to capture the real picture when applied to physical hardware. With information technology, most of the costs are not in physical assets but ongoing maintenance and operations costs. People, applications, and assets must be measured together.

Another part of the problem with total cost ownership is that it is far too easy to focus on costs while ignoring value. Information technology professionals have not been successful in extracting value benefits as a story to tell to management. If the value portion of the equation is lacking, then the only "real" item for management to examine is the cost portion. The cost number is an easy read for management. The problem is to develop TCO data that will result in decisions that make sense not just in executive reports.

The other problem often unaddressed is that technology is misused in ways that are detrimental to productivity. An example would be e-mail. How much of the average person's e-mail received in the business setting is really valuable for your job? How much of the e-mail is simply garbage? Everyone receives junk mail at home and at the office. Fortunately, junk e-mail can be readily deleted while holding on the phone or listening, a key advantage. In offices, phone abuse and office copier abuse have spawned e-mail abuse, where jokes are forwarded. With the Internet, one can read the daily newspaper in his cubicle on computer while appearing to be at work.

A cost approach faces problems because it only looks at costs. How do we look at value? Ideally, value derived from information technology should be able to be derived from productivity numbers. Again, productivity is simply outputs divided by inputs. Total productivity must not only include labor hours as inputs but also raw materials, shop hours, and other factor inputs. If the task can be viewed as standalone before information technology, then after, productivity should be seen to increase. If the technology were taken away, what would managers be willing to pay for the technology. Again, the value of the technology to managers should exceed the costs of the technology. There should be positive leverage from the imposition of the technology. This approach requires a step-by-step documentation of the work processes and then assigning costs and values to these processes.

TOTAL COST OWNERSHIP: OFTEN-IGNORED ELEMENTS

While direct expenditures for hardware and software are relatively easy to measure, what about other elements of the cost puz-

zle? What about technical support and administrative activities? If the organization has a help desk, this is an obvious item for inclusion in the TCO calculations. However, if there is a user group that meets on company time or other meetings that find themselves concerned with information technology, costs should be allocated to these activities. Items such as application development, whether done in-house or subcontracted, become part of the cost structure. Total data center costs such as construction and operations, including energy costs for center cooling, should be included in this mix. Other operations and maintenance costs down to security personnel and janitorial staff also become part of this mix. Unfortunately, this level of detail may not exist for certain organizations. Costs for janitorial and security functions may be rolled up on an organizational macro basis and not allocated to individual functions. To achieve the total cost picture, estimates may have to be made based on staffing levels and square footage calculations for information technology functions.

When analyzing the costs of data centers, it should be noted that capability and capacity have rapidly increased, while actual costs of operation have dramatically decreased. The present data centers built now because of technology require far fewer people to run than the first centers. It is estimated that a current data center comprises 80 percent capital costs and only 20 percent personnel costs. With the distributed computing model, capital costs are 30 percent with 70 percent comprising personnel costs [2].

The other part of calculating the total cost ownership picture is where would these costs be if information technology didn't exist? Costs in certain areas, such as the security staff on the front gate, wouldn't change if information technology vanished today. Offices and cubicle space wouldn't shrink if personnel lost their computers today. In fact, a sound argument can be made for the proposition that electronic storage by diskette, CD-ROM, magnetic tape, or other means consumes far less space than paper. Moreover, electronic databases and other electronic files can be searched more efficiently than their paper representations.

The other side of the problem with TCO calculations on information technology is that technology has so embedded itself into most business functions that it is impossible to separate out. Many processes cannot run with information technology. An example would be a manufacturing firm that I worked at that implemented information technology through process control on some production lines. At first there were numerous hardware and software bugs in the system. Production personnel bitterly complained about the problems. However, once the problems were eliminated, the control console operator could sit back after pushing a few buttons and the technology automatically took the facility up to run speed. The problem was that quality demands of customers increased in the meantime. When problems were now encountered with the technology, the production personnel could not run the equipment on manual and still meet the increased quality demands. How does one measure the value of this information technology in the production facility case? Most are familiar with reading of system shutdowns for organizations such as stock exchanges and websites due to glitches with infrastructure backbones.

FRICTIONAL COSTS

Another aspect of the TCO picture is frictional costs. Frictional costs are created when end-users have problems with the technology. These problems of technology use by the end-users may have to do with lack of training. Training costs are a real cost. The cost of a 2-day computer software class can be measured both by the physical costs of the class and the time the attendees spend away from their jobs. These are the easy costs to measure.

What about frictional costs? Frictional costs are defined as the time that end-users spend at their desks making mistakes or trying to correct mistakes because they don't understand the technology. Differing elements of the technology may be incompatible with each other. Part of these frictional costs come in the form of time that coworkers may spend trying to help out another end-user. The other part of the frictional cost issue is end-users not using the technology to its full extent. An end-user may be using a word processing or spreadsheet program but only to 10 percent of its capability. Take a large organization with 5,000 end-users on desktop and laptop machines who are not trained in the particular organization's software applications. These frictional costs could amount to 100 hours per end-user per year. These frictional costs thus total 500,000 workhours per year. Potentially, information technology training in year one for 30 hours total could save half of these frictional costs over a 3-year period (before the technology changes). The frictional cost calculation is given in table 1.

With a net savings of half the frictional costs through improved training, the savings net out to 600,000 hours, which at 2,000 hours per year, would be the equivalent of 300 people. Unfortunately, attitudes about adequate training are very negative. Too many managers adhere to the adage "but what if we train them and they leave?" The retort of Bob Lewis, **Infoworld** columnist is, "what if we don't train them and they stay [4]?"

Some frictional costs can be traced to a lack of standards. An organization may have users with three different word processors or three spreadsheets or three scheduling packages. Trying to move a spreadsheet between different products may involve complications such as data incompatibilities. Frictional costs go up dramatically with the lack of standardized software across the organization.

Other frictional costs take place due to bugs in software that create errors. While some bugs are relatively harmless, some can be very expensive. One construction firm using a bid analysis package from a prominent software firm ended up with a bid that was $1.95 million too low. Unfortunately, the software vendor was able to get the case tossed out of court by arguing that the software license disclaimed all liability [3].

Table 1

Item	Time	Amount	Period	Total Hours
Training time	30 hours	5,000 end-users	1 year	150,000
Frictional costs	50 hours	5,000 end-users	3 years	750,000
			Net difference =	600,000
			600,000/2000 =	300 people

INFORMATION TECHNOLOGY STANDARDIZATION

When stating the need for standardization, this goal can only be carried so far. Technology from both the hardware and software sides changes so rapidly in today's environment that true standardization is impossible to achieve. A group of the same laptops bought today will be slightly different than those purchased last month. Processor speeds, memory, and other aspects of feature sets will change. The same principle applies to software. Manufacturers in these areas are continually enhancing their products. Thus, at the outset, when standardization is discussed, it is in the context of trying to achieve a degree of standardization rather than the copy-exact variety.

A subset of the TCO problem is the lack of standardization found in many organizations involving information technology. In the dominant days of mainframe and midframe computing, standardization was easy for organizations because there were relatively few pieces to the puzzle. The advent of PC-centric computing in the early 1980s created a number of problems. Personal computers became inexpensive enough that managers could buy them out of departmental funds. The same applied to software. Information systems departments in firms that had them in some cases lost the battle for control. While the PC-centric model yielded more freedom for end-users, the lack of standardization created many problems. Among these problems were service and maintenance issues. A nonstandard software package or multiple packages would be added to PCs in one area, with resultant problems. The systems department would be called in to solve the problem created by the end-user department. Issues such as asset management in this nonstandardized environment become much more challenging.

The other part of the standardization issue is the increasing variety of hardware platforms. The PC-centric model started off at the desktop and migrated to include the laptop. Now with personal digital assistants (PDAs) and cell phones becoming more like computers, who becomes responsible for these added devices? PDAs can be turned into cell phones. How to design an efficient information technology infrastructure in the face of all this variety is an issue perplexing many firms.

The problems of nonstandard hardware and software are many in information technology. The complexity with many assets is that both service and warranty issues suffer in this lack of standardization. Management has no idea what items are under warranty or may be covered by service contracts. End-users may not know enough about service issues, or you have overlapping service contracts. Ideally, like a set of plans and specifications, there should be no gaps or overlaps in these areas.

The most common problem with standards is that any standard selected will not be right for all users. This deficit is true in both hardware and software. In software particularly, before selecting a standard desirable feature, competing software offerings should be evaluated on a thorough basis. End-users should realize that in many software areas they may only get 80 percent of the features they want. One criteria many firms use is to choose the industry leader in any category as their standard product of choice for software. Hardware can be easier, but the choice should narrow down to a tier 1 provider as categorized by the Gartner Group. Standardization involves the risk that a standard selected depends on the viability of the particular vendor. If the vendor goes out of business, the costs for any organization with a sizable user base are significant. In addition, organizations should avoid custom software unless the programming effort to accomplish this is truly trivial. Finally, user satisfaction surveys can be important for the organization in deciding overall direction. Some organizations e-mail periodic surveys to users asking for their opinion of hardware and software issues. Every user who does not either turn in a positive vote or does not vote receives a follow-up phone call from the systems group to ascertain their IT concerns.

Attempting to keep up with technology is difficult. Organizations need to tread a line of being behind the curve or too far out in front of the pack in adopting new technology. How to select that correct location is problematic. End-users will read about the latest and greatest product and want it to use immediately. With a new software release there may be significant bugs that could create havoc with a computer network or other software. Just simply because a product is standard, before users are allowed to have the latest release of the standard installed, the system must be tested adequately.

The other key aspect of standards is that IT support people become experts in a shorter timeframe than otherwise because there are fewer tools to support, whether hardware or software. Standardization can include a standard image along with a standard configuration of not only the applications and versions, but also a standard directory. The standard directory aspect makes the IT support area more efficient, lowering the overall IT cost structure.

BUY VERSUS LEASE

Buy versus lease of information technology can be a difficult decision. One advantage of leasing is that with common 24-month lease terms, hardware can be turned over very quickly for the organization. Thus, hardware is always up to date. Some vendors provide leasing of software applications. Leasing may not reduce total costs and may even be more expensive. However, now the organization has a flat rate cost for this every month, plus it can take advantage of expensing certain costs.

SOFTWARE LICENSE COMPLIANCE ISSUES

The proliferation of computers and software in the workplace has led to widespread pirating of software. People who wouldn't think of stealing something of tangible property don't think twice about copying software from one PC to another. The stealing of intellectual property via the copying of software is somehow not viewed as a crime. An organization may have a fairly broad site license for a software package, but with growth the site license numbers have not kept up with the numbers of PCs that now host this software. End-users may think that they can port this software to unlimited machines since "we have a site license." Besides the illegality of copying software, organizations have been successfully sued in court by software firms or trade associations or otherwise forced to pay monetary damages because of a failure to adhere to software licensing strictures. Often the source of the knowledge of the copying comes from disgruntled present or former employees. Obviously, a significant amount of negative publicity can be gen-

erated. In addition, settlement terms in certain instances have required the dismissal of responsible employees.

Software license noncompliance is a poor way to attempt to reduce the costs of information technology.

THE IDEAL TOTAL COST OWNERSHIP MODEL

As noted above, a focus just on costs with no examination of benefits yields an incomplete picture. Value must be factored in to any discussion on information technology. Total costs minus total benefits should equal the total value of the information technology. This calculation should not be static but instead be continuously measured on a dynamic basis.

$$TVO = TBO - TCO$$

where
TVO = total value of ownership;
TBO = total benefits of ownership; and
TCO = total costs of ownership.

(equation 1)

Whether an organization is involved in the outright purchase of information technology or rents or leases these items, the costs are loaded into the above equations as ownership costs. A rent payment or lease payment or purchase payment aside from tax considerations still means that the firm for all intents and purposes has a stake in the particular item.

In figure 1, total costs of ownership for an example firm that has PCs on a network are shown. Two items are of particular note. Frictional costs are approximately 20 percent of the total cost structure and infrastructure support costs consume the largest share of the pie at 45 percent. Many firms, before studying this issue, feel that hardware/software costs would be the predominant issue.

Correctly measuring total cost ownership for many organizations can be a very complicated endeavor. The key cost elements lie outside the obvious factors of hardware and software. The value aspect, once costs are subtracted against benefits, should yield a positive number as outlined in the equation. If the value is not positive, the organization may need to rethink its information technology strategy.

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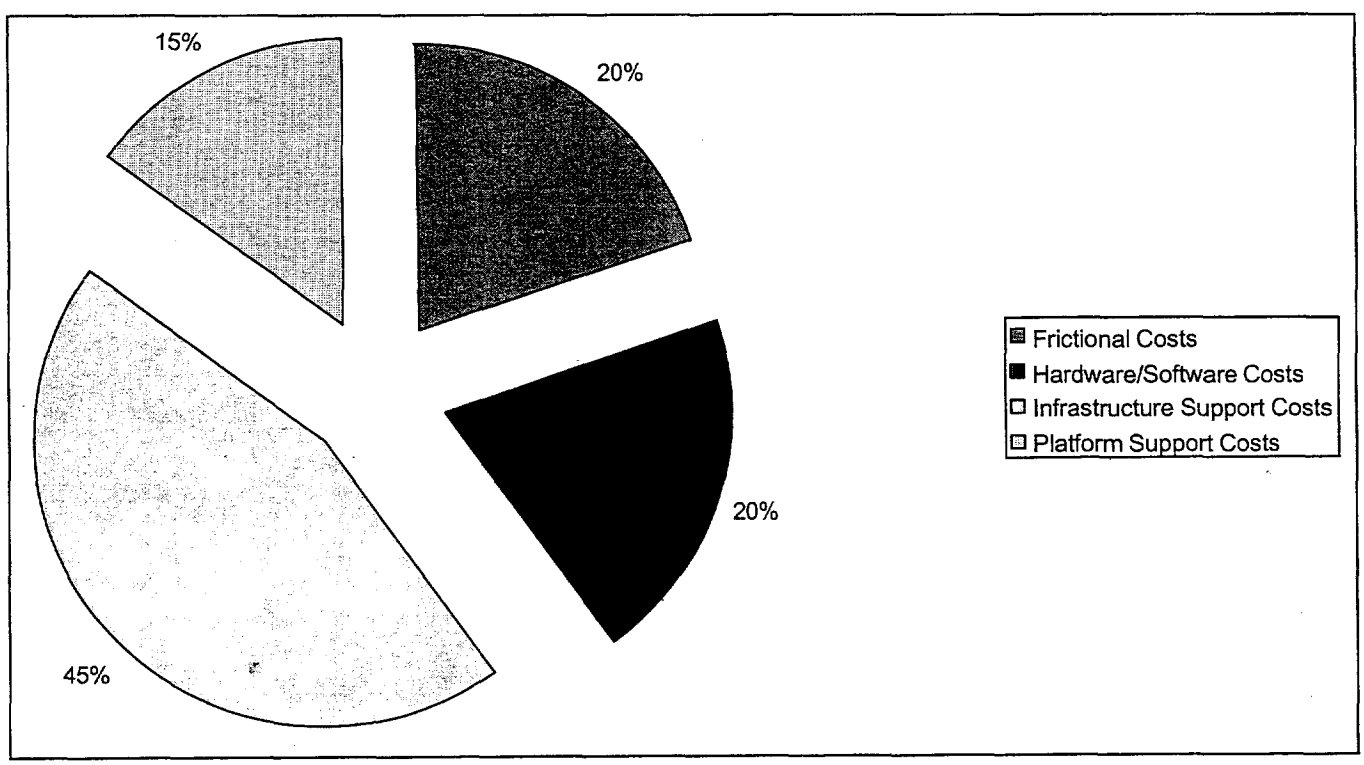

Figure 1—Total Costs of Ownership for a Sample Firm

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