THE ECONOMICS AND COST JUSTIFICATION OF ERGONOMICS

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ABSTRACT

The language of business is dollars, and in today's business climate successful ergonomists know that cost-justification of ergonomic interventions/programs is essential. Performing a cost benefit analysis is an important skill for all health and safety professionals. The purpose of this project is to demonstrate how ergonomics affects the business drivers of quality and productivity and how a cost-benefit analysis can be used to justify ergonomic interventions in the workplace. The National Occupational Research Agenda priority addressed in this project includes Social and Economic Consequences. Specific research priorities addressed include economic consequences to employers, macroeconomic impact, and cost outcome analysis. This project includes a discussion on current quality operations, management issues, and the role that ergonomics plays in product quality maintenance. An explanation of how ergonomics can reduce product quality costs will be included. Additionally, we will illustrate how ergonomic principles can lead to improved productivity and reduced corporate labor costs. In order to cost-justify ergonomic interventions, the full representative injury costs must be determined. An explanation of both the direct and indirect costs of injuries will be included in this project. Cost benefit analysis methods including internal rate of return, return on investment, and payback period will be presented, as well as how these methods are used to cost-justify ergonomic interventions. Finally, strategies for justifying ergonomic interventions will be presented and illustrated with real world examples. Not only does ergonomics play a vital role in injury reduction and prevention, but economically effective ergonomic principles can lead to improved corporate financial performance and strategic competitive advantage.

INTRODUCTION

The application of simple ergonomic principles can reduce costs such as workers' compensation, absenteeism, employee turnover, and product quality defects. Improved ergonomic workplace designs that can lead to fewer errors and product defects can improve business operation efficiency. New products and services can be brought to market with diminished costs and reduced liabilities. Use of ergonomics can also earn money for the business. Manufacturers can utilize ergonomic principles to produce products that are more useful and appeal to more buyers. Increased buyer appeal leads to improved sales (MacLeod, 1995).

In today's competitive market, this message has not been effectively communicated. Businesses continue to question the science behind ergonomics and the reduction of occupational injuries. However, injury reduction is not the only goal of ergonomics. Businesses should also understand that ergonomics can lead to an improved bottom line and competitive edge. The Federal Ergonomic Standard of 2000 was abolished by presidential executive order due to strong pro-business lobbying efforts. The Washington State Ergonomic Standard was recently narrowly voted down due to a strong pro-business, anti-ergonomics lobby effort. The argument was not made that sound ergonomic principles can result in improved bottom line performance. Ergonomic proponents should place a stronger emphasis on demonstrating the economic benefits of sound ergonomic principles. These efforts should be in conjunction with the demonstration and communication of the proven effectiveness of ergonomics in reducing or preventing workplace injuries.

A need for cost justification has recently become a reality for health and safety professionals. The purpose of their programs, specifically ergonomics, is to improve employee health by reducing or eliminating hazardous exposures. This aim has been important enough to obtain funding in past decades. Consequently, the health and safety field has not focused its skills and data acquisition systems to support cost-benefit statements that result from their endeavors. As a result, ergonomics is frequently seen as an expense. Proponents of ergonomics have successfully argued that its practice can effectively reduce or even eliminate on-the-job injuries. However, when companies are tightening their expense budgets, ergonomic proponents have too often failed in justifying the cost of ergonomic interventions. The practice of cost-effective ergonomics can lead to improved organizational financial performance, as well as contribute to the achievement of a sustained strategic competitive advantage. In order to make this argument, health and safety professionals must fully understand as well as communicate the financial costs of injury - both direct and indirect. They must also be able to effectively cost justify their ergonomic proposals in order to obtain adequate funding.

PURPOSE

The purpose of this project is to address research priorities as set forth by The National Occupational Research Agenda (NORA), specifically Social and Economic Consequences. Specific research priorities addressed include economic consequences to employers, macroeconomic impact, and cost outcome analysis.

MACROECONOMIC COSTS OF OCCUPATIONAL INJURIES

From a macroeconomic perspective, the national economic financial burden due to occupational injuries has been well researched. According to the National Safety Council (2003), the total cost of occupational injuries in 2002 was estimated at $146.6 billion. This amount includes wage and productivity losses of $74.0 billion, medical costs of $27.7 billion, and administrative expenses of $26.3 billion. This figure also includes $12.5 billion in employer costs of time lost by workers (other than those with disabling injuries) who are directly or indirectly involved in injuries, and the cost of time required to investigate injuries, write up injury reports, etc. In 2002, total days lost due to work injuries was estimated to be 125,000,000. It is apparent that occupational injuries have a strong influence on the health and wellbeing of the national

economy and society as a whole. In addition, occupational injuries can directly influence the ability of the nation to compete with other nations in the international marketplace.

MICROECONOMIC COSTS OF OCCUPATIONAL INJURIES

In order to justify ergonomic proposals at the company level, occupational injuries must be researched from a microeconomic perspective. Specific companies must have an organized injury cost capturing methodology. These historical costs can be used for cost benefit analysis purposes. If historical costs are not available or accurate, published costs from reputable and corporate-accepted organizations can be used. The National Safety Council publishes workers' compensation claim costs in its Injury Facts Publication. These injury claim costs are broken down according to average injury claim cost by cause of injury, nature of injury, and part of body. For example, according to the National Safety Council Injury Facts Publication (2003), the average total incurred cost per injuries to the lower back for the years 2000-2001 was estimated to be $14,913. This figure could be used in cost benefit analyses to project the potential cost avoidance savings of a lower back injury due to a proposed ergonomic intervention.

If a company is inclined to capture the costs of its injuries, the company must realize that there are many component costs to each injury. As with any organizational project, costs must be categorized into direct and indirect costs. Ergonomic proposals are no exception. Direct costs are easier to trace to a particular product than indirect costs (McWatters, Morse, and Zimmerman, 2001). Below is a breakdown of direct and indirect costs of injuries in the workplace:

Direct Costs

- Insurance premiums (if insured)
- Lost wages, medical expenses, rehabilitation (if self-insured)

Indirect Costs

- Uninsured costs not covered by insurance (workers' compensation)
- Cost of wages for workers' compensation waiting period
- Time lost on day of injury
- Time spent at, and traveling to and from, doctor visits
- Time spent at, and traveling to and from, rehabilitation
- Reduced output after return to work until 100% performance is achieved
- Cost of overtime to pick up slack of injured worker
- Time lost by non-injured workers
- Reduced output of replacement employee(s)
- Time-cost of supervisor for management of injury
- Time-cost of safety professional for injury investigation and presentation
- Time-cost of human resources to manage injury
- Damage to equipment and/or materials (Schulze, 2000)

The direct to indirect cost ratio for all U.S. industries is estimated to be 1:4 (MacLeod, 1995). Therefore, by using only the more easily captured direct costs, the true costs of injuries can potentially be grossly underestimated. It is in the best interest of the company to take all

measures possible to capture both direct and indirect costs of injuries in order to achieve accurate injury cost estimation.

Table 1 depicts the amount of sales volume needed to offset the cost of an injury at different levels of profit margin (Washington State Department of Labor and Industries, 2000). For example, a construction company operating at a 2% profit margin would have to increase sales by $500,000, to pay for a $10,000 injury (.02 x 500,000 = 10,000).

Cost of Injury ($)	**Budgeted Profit Margin**				
	2%	**4%**	**6%**	**8%**	**10%**
10,000	500,000	250,000	167,000	125,000	100,000
50,000	2,500,000	1,250,000	833,000	625,000	500,000
100,000	5,000,000	2,500,000	1,677,000	1,250,000	1,000,000
500,000	25,000,000	12,500,000	8,333,000	6,250,000	5,000,000
1,000,000	50,000,000	25,000,000	16,667,000	12,250,000	10,000,000

Table 1. Total sales needed to offset the cost of injury (Washington State Department of Labor and Industries, 2000).

Extensive research has been conducted that proves ergonomics reduces or eliminates the risk factors associated with occupational injuries. Most workers' compensation costs are associated with injuries that ergonomics can help prevent, including back injuries, wrist disorders, and assorted strains and sprains. Preventing costly cumulative trauma disorders has been an ergonomics priority in recent years. Implementing sound ergonomic principles has a proven track record of substantially reducing the costs of injuries (MacLeod, 1995).

QUALITY COST REDUCTION

There are many operations management "trends" that are designed to improve overall product quality. The ergonomics proponent needs to be keenly aware of every operation's management technique, and be able to relate each ergonomics proposal to whatever technique the company is currently using. The majority of American quality management techniques evolved from Total Quality Management (TQM) techniques, which is based on the writings of Edwards Deming. The basic idea behind TQM is that it is extremely expensive to "inspect" the quality of a company's outputs and much more efficient and effective to produce them correctly in the first place. Other quality management techniques that have resulted from the TQM movement include reengineering, Six Sigma, lean manufacturing, ISO 9000, removal of middle management, and worker empowerment (Meredith and Shafer, 2001). One must realize that all quality management approaches have an interdependent relationship with ergonomics. The ergonomics proponent must understand and effectively convey that poorly designed workplaces not only set the stage for worker injury, but also place the worker at a production disadvantage. By reducing ergonomic deficiencies, workers can perform more efficiently (MacLeod, 1995). Ergonomics often finds ways to eliminate or reduce the non-value-added elements of a job. As a component of TQM, ergonomics plays an instrumental role in the overall operations management program (Braun, 1994). By incorporating a participatory approach for problem-

solving and continuous improvement, jointly focusing on ergonomics and quality has great potential for simultaneously improving working conditions and quality results, and satisfying most of the organization's interested parties (Eklund, 1997).

Ergonomics can help to reduce product defects that result from the manufacturing process. People working in awkward positions are at a working disadvantage and are not in a position to perform their jobs correctly. Errors might be common and rework might be needed (MacLeod, 1995). For example, suppose that it costs a company $2,000 to scrap a product due to quality defects and it is proposed that ergonomic changes can reduce the scrap rate by 50%. The following is an example of how improved quality due to ergonomic interventions might be projected into savings (Table 2).

	Existing Rate	Projected Rate	Projected Increase
Damage /Scrap Rate	0.1 units / week	0.05 units / week	$100 / week x 52 weeks $5,200 savings annually

Table 2. Projected savings.

PRODUCTIVITY COST REDUCTION

It is in the producer's advantage to keep absolute costs as low as possible. This allows the company to offer products at the lowest possible price while still making a profit. Offering a low-cost product allows the company to remain competitive within a price-sensitive market. The primary method of keeping costs low entails the concept of productivity. Productivity is a special measure of efficiency and is normally defined as output per worker-hour. There are two major ways to increase a firm's productivity: increase the numerator (output) or decrease the denominator (worker-hours). Productivity would also increase slightly if both factors increased but output increased faster than worker-hours, or if both factors decreased but worker-hours decreased faster than output (Meredith and Shafer, 2001).

Many factors can influence productivity. In a Finnish study where the productivity of small to medium sized organizations was investigated, numerous factors were found that influence the productivity of the organization. Identified factors included management and participation, work content and motivation, working atmosphere, ergonomics, work orientation, housekeeping, lighting, temperature conditions, and noise (ILO Safework, 2002). Poor working conditions can lead to productivity losses in many ways. Losses can come from poor work methods, potentially injurious work conditions, and/or work conditions that leave workers incapable of their best performance. Costs include overtime and/or over-employment required due to absence and/or caused by the poor work, methods, or conditions. Other costs include the direct cost of loss of product, increased warranty costs and repairs, substitution, and an indirect cost of loss of customers (Oxenburgh, 1997).

Productivity can be enhanced through the implementation of ergonomic principles. Productivity improvements result in cost reductions and improved organizational value. It might be easy to comprehend how ergonomics can improve productivity in a manufacturing setting, where tangible products are constructed; however, in an office setting, as well as service-oriented

companies, it might be more difficult to prove the productivity benefits of ergonomics. Smith and Bayehi (2003) conducted a study using computer office workers in distribution and call centers in the United States Midwest. The authors found that worker productivity increased from 2.4% to 9.4 % for those who received ergonomic improvements to their workstation. Increased memos/documents produced, service calls taken, and customer help calls are all ways to measure improved office worker productivity.

In the construction industry where a high injury rate exists, even a small increase in productivity on the order of five percent can have a significant impact on the profitability of the construction firm. Table 3 is a breakdown of a bid for a construction project.

Bid Cost Component	Cost %	$1 Million Project
Field Labor Cost	40	$400,000
Material Cost	35	$350,000
Equipment Cost	7	$70,000
Job Overhead (General Conditions)	8	$80,000
Company Overhead	8	$80,000
Profit	2	$20,000
TOTAL	100	$1,000,000

Note. Assume a 5% increase in Construction Productivity

Labor Cost Savings = (5%) x ($400,000 of labor cost) = $20,000

A 5% increase DOUBLES planned profits

Table 3. Impact of productivity increase on profitability in a construction project (Adrian, 2002).

A budgeted two percent profit or $20,000 is a typical profit margin in the bid if the company overhead component is deleted from the overall bid/estimate. A five percent increase in productivity would have the effect of decreasing the overall project labor cost by five percent. As illustrated, a five percent increase in productivity and a corresponding five percent decrease in labor costs would result in a profit contribution equal to the initial planned profit. The end result is that a small five percent increase in productivity can have the result of doubling the profits of the construction firm (Adrian, 2002).

As an additional example, suppose that it costs $0.10 to produce one unit (or $50 to produce 500 units per hour) and proposed ergonomic changes can improve productivity by 10%. In addition, the company projects that 1,000,000 units will be produced during the fiscal year. Where it once cost the company $100,000 to make 1,000,000 units, it now would cost the company $90,909 to produce the same number of units (a savings of $9,091). The following (Table 4) illustrates how improved productivity due to ergonomic interventions might result in projected savings.

	Existing Rate	Projected Rate	Projected Savings
Productivity Rate	500 units / hour $50 / 500 = $.10	550 units / hour $50 / 550 = $.091	$100,000 - $90,909 = $9,091 annually

Table 4. Projected savings.

COST BENEFIT ANALYLSIS

Most businesses require a project cost benefit analysis before approval is granted by management. Ergonomic proposals should be no exception. Performing a cost benefit analysis can be somewhat confusing to someone without a business background. This type of analysis can be viewed as a technique that allows for the determination of whether the benefits of a given alternative outweigh the costs, and thus whether the alternative is worthwhile. It also allows for the comparison of several alternatives to determine which provides the greatest number of benefits relative to its costs (Levin and McEwan, 2001).

The benefits of an ergonomics proposal can include improved productivity, improved product quality, and reduced injuries. Several other benefits can be included, but these three are more easily captured in monetary terms and can more easily be traced back to ergonomic changes. The costs of an ergonomics proposal include those expenses incurred to implement the ergonomics project. Of course, all of the projected costs and benefits need to be expressed in monetary terms for calculation purposes. In addition, the costs and benefits can be spread out over a course of months or years.

A principle that should be understood is the discount rate. Future cash flows (benefits and costs) should be discounted when they are compared with present cash flows. This is due to the fact that future monetary values are not the same as present values due to inflation. Usually the discount rate should be the opportunity cost of capital. Therefore, the present value of a future cost or benefit can be expressed as:

$$\text{Present Value} = [1 / (1 + r)^n] \times \text{Future Cash Flow} \quad (1)$$

where r is the opportunity cost of capital and n is the number of time periods that separate the present and the future cash flow (usually years). The opportunity cost of capital is usually company-specific and is the same established rate used in all cost-benefit analyses (Meredith and Shafer, 2001).

Three of the more common cost benefit analysis techniques include the Internal Rate of Return (IRR), Return on Investment (ROI), and Payback Period (PP). The following discussion briefly describes each of these techniques. Business texts are a good reference if a more specific and detailed explanation of these techniques is needed.

Internal Rate of Return

The Internal Rate of Return method finds the interest rate that equates the initial investment for the ergonomic project to the future discounted cash flows. In other words, the IRR makes the net

present value (NPV) equal to zero. If the ergonomic project's internal rate of return exceeds a certain cut-off rate (e.g., the project's cost of capital and is company-specific) the project should be undertaken (McWatters et al, 2001). The IRR is quite easy to calculate if an initial cash outflow (cost of the ergonomic project) is followed by a cash inflow in one year. For example, a company can invest $1,000 on an ergonomic project and receive $1,070 in benefits (savings) in one year. The IRR sets the investment cost equal to the discounted future cash flow:

$$\text{Investment cost} = (\text{Cash inflows or savings in one year}) / (1 + \text{IRR}) \quad (2)$$
$$\$1{,}000 = \$1{,}070 / 1 + \text{IRR}$$
$$(1 + \text{IRR}) = \$1{,}070 / \$1{,}000$$
$$\text{IRR} = .07 = 7\%$$

In this example, if the company-specific cost of capital is 5%, the ergonomic investment proposal exceeds the cost of capital (7% vs. 5%) resulting in an investment return in excess of its costs. Therefore, this project should be undertaken. Multiple year project IRR's are calculated using statistical software such as Excel or even a simple financial calculator.

Suppose, for example, that an ergonomic proposal is made that requires $2,000 initially and has potential cost savings extending three years into the future. Productivity and quality cost savings are those obtained in previous examples. Historical injury cost values or a published injury cost average can be used in the analysis to estimate savings due to an injury avoided as a result of the ergonomic change. In this example, the average low back injury cost of $14,913 is used. This figure is obtained from the National Safety Council 2001-2002 Injury Facts (2003). Suppose that the ergonomic proposal conservatively projects that one low back injury is prevented due to the intervention. The following table (Table 5) illustrates the future cost savings that are used to compute the ergonomic proposal IRR.

	Year 0	Year 1	Year 2	Year 3
Initial Project Costs	$2,000			
Injury Cost Savings			$14,913	
Improved Productivity		$9,091	$9,091	$9,091
Reduced Defects (Improved Quality)		$5,200	$5,200	$5,200
	($2,000)	$14,291	$29,204	$14,291

Table 5. Projected cost savings from proposed ergonomic intervention.

Using a financial calculator, the IRR is calculated to be 788%. Compared to more common business proposals, this is a relatively large IRR. However, it proves that ergonomic costs that are typically low can lead to cost savings, which primarily come in the form of injury cost avoidance, and productivity and quality improvements. This IRR far exceeds the company-specific IRR of 15% and, therefore, the project should be accepted.

Return on Investment

A second cost benefit analysis technique is the Return on Investment. The ROI of an ergonomics proposal can be easily calculated by the following equation:

ROI = Earnings or savings from Project / Total Initial Investment (3)

If the ROI exceeds the company-specific cost of capital, the project investment increases the organization's value and the project should be undertaken (McWatters et al, 2001). For example, if the initial cost of an ergonomics proposal is $3,000, and the projected cost savings are $2,000 in injuries avoided, improved productivity, and improved product quality, the ROI is calculated by the following:

ROI = $2,000 / $3,000 = .666 = 66.7% (4)

If the company specific cost of capital in this example is 10%, the ergonomic proposal should be accepted. ROI has some drawbacks compared to the IRR method. ROI does not recognize that future cash flows cannot be equated to present values. However, companies often prefer the ROI method over the IRR purely because of its simplicity.

Payback Period

The third technique often used in a cost-benefit analysis is the Payback Period. The Payback Period is the number of years or months that it takes for cash inflows or savings from an ergonomics investment to equal the initial investment cost. The payback period should be as short as possible to release investment dollars that could potentially be spent on other moneymaking projects (McWatters et al, 2001).

Suppose that an ergonomics project costs $2,000 initially, and subsequent projected yearly cash flows are $1,000, $2,000, and $2,000. The project has returned $1,000 after one year, and the remaining $1,000 can be returned in .5 years. Therefore, the total payback period is 1.5 years.

Payback ignores the opportunity cost of capital and also ignores all cash flows beyond the payback period. Thus, payback ignores the project's "profitability." However, the payback period does show how long investment dollars are wrapped up in a particular project. Each company usually has established maximum payback periods for proposed projects before project acceptance is granted.

STRATEGIES FOR ERGONOMIC JUSTIFICATION

It is truly noble when companies attempt to reduce injuries out of genuine concern for employees. At the very least, injury reduction and prevention is the ethical thing to do. However, the benefits reach far beyond the personal health and safety of individuals. Ergonomics is good business practice, and can effectively contribute to the economic well-being of the company. Including economic justification will dramatically improve the chances of obtaining funding for ergonomic proposals. Most ergonomic proposals that both reduce injuries and have desired economic benefits are typically implemented without question. The ability to provide economic justification makes approval of recommended changes easy, thus permitting safety and health improvements and financial benefits. Ergonomists and engineers should be

capable of presenting an economic as well as technical argument to justify recommended ergonomic improvements.

Prior to attempting to justify an ergonomic improvement, the safety officer must ensure that the cost of the improvement is as low as possible. There are two reasons for this. First, it is always prudent to obtain the best value for the dollar spent. Most ergonomic situations involve solutions that range from a few dollars to thousands of dollars. The effectiveness of the solution does not always correlate with the cost of the solution. Frequently, a highly effective solution can be achieved at a low cost. One method to review ergonomic cost effectiveness is the "value/cost matrix". This matrix allows a review of the relative ergonomic effectiveness versus the cost, thus allowing safety officers to choose the most appropriate solution. The ultimate goal is to find the most effective ergonomic intervention with the lowest cost (Alexander, 1998).

Second, for many organizations, justification is not required below a certain threshold. Work orders up to $500 or $1,000 are usually approved without the need for cost justification or administrative approval. This is a very powerful reason to develop ergonomic solutions that are relatively inexpensive. Fortunately, many ergonomic solutions do, in fact, cost less than $1,000. Data reported from a review of 49 ergonomic projects are shown in Table 6. The goal of each of these 49 projects was to resolve the problem at minimal costs. Almost 70% of the possible solutions were less than $1,000 (Alexander, 1998).

Cost per Project	Number of Projects	Cumulative Percentage of all Projects
Less than $100	11	22%
$100 to $500	12	47%
$500 to $1,000	11	69%
$1,000 to $2,000	7	84%
$2,000 to $5,000	7	98%
More than $5,000	1	100%

Table 6. Cost of resolving ergonomic improvements (Alexander, 1998).

If a company has a poor safety practice, even small investments may have major payoffs, with ergonomic interventions possibly being the most profitable (ILO Safework, 2002). Ergonomists should strive to avoid the automation mentality in which the preferred solution to each problem is to remove the person from the task. Rarely is automation the most appropriate solution (Alexander, 1998).

Another important issue is timing of ergonomic implementation. Reduced design and construction costs can be obtained when equipment and facilities are designed correctly the first time. The cost of correcting ergonomic design during the initial part of a design project is approximately 10% of the cost that will occur later in the project implementation (Alexander, 1998).

CONCLUSION

Health and safety professionals all too often believe that organizational decision makers proactively support ergonomics simply because it is the right thing to do. It is hard to argue against doing anything that may better the human condition, and so this alone should be a compelling argument for actively supporting the use of ergonomic principles. In reality, managers need to be able to economically justify any investment in terms of its concrete benefits to the organization's ability to be competitive in its market. Effective ergonomics programs not only benefit and protect the organizations that implement such programs, but also promote the interests of United States companies in a globally competitive environment (American Society of Safety Engineers, 2002). That something "is the right thing to do" is, by itself, an excellent but insufficient reason for managers to support ergonomics. In his 1996 Presidential Address at the 40th Annual Human Factors and Ergonomic Society Annual Meeting, Hal W. Hendrick stated, "we have done a poor job of documenting and advertising the cost-benefits of good ergonomics—of getting the word out that most often, good ergonomics is good economics" (Hendrick, 1996).

Health and safety professionals need to take a proactive approach with respect to justifying ergonomic proposals from an economic perspective. The true cost of injuries, absenteeism, and poor productivity and quality must be fully understood. Additionally, the positive influence that ergonomics can have on reducing these negative factors must be recognized. Cost benefit analysis should be used to economically justify ergonomic proposals. This will enable the ergonomist to assist corporate managers by providing them with cost-saving information that is relevant to the survival and success of the corporation. Four reasons have traditionally been used to justify ergonomic principles:
1) injury reduction/safety improvement, 2) improvement in the overall quality of worklife, 3) improved product quality, and 4) improved production efficiency/ productivity. It can be argued that a fifth reason for ergonomic justification is the contribution to the profitability and strategic competitive advantage of the company. Ergonomics is good economics, and should be justified from both a humanitarian and an economic standpoint.

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