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# Quantifying the intangible costs related to non-ergonomic work conditions and work injuries based on the stress level among employees

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A B S T R A C T

Undoubtedly, no specific method exists to measure the cost of displeasure among employees due to unpleasant or non-ergonomic work conditions. Despite the financial impact of these hidden costs on organizations' performance, these types of expenses are usually ignored. The intangible costs are insubstantial and represent expenses that have no common quantity or labeled value attached to them. Estimating intangible costs related to work conditions based on stress level among employees is a technique that attempts to formulize a multidimensional relationship between input qualitative variables related to the state of work conditions or work injuries and the monetary value of the hidden costs encountered with them. This technique approaches the problem from a unique standpoint, revealing the concealed effect of the state of disorder of the production system and the stress level among employees that impact the overall efficiency. In addition, the influence of the stress level on the invisible costs of the optimal amount of labor and capital due to reduced ergonomic work conditions will be investigated over both the short run and the long run. Finally, the effect of work conditions on profit-cost-volume and the breakeven quantity will be formulated.



## 1. Introduction

In today's competitive global economy, attempts to reduce production costs are a serious priority for most industries. The fluctuations in raw material and fuel price and the tumbling in sales rates stimulate companies to develop policies to guide and control their expenses. The costs of work injuries and the effect of non-ergonomic work conditions are major contributors to the overall expenses. Worldwide, there are more than 270 million work accidents and 2 million deaths due to work injuries or work related diseases yearly (TC-OSH, 2013). The unquestionable economic impact of these work condition related injuries are massive at the individual, enterprise, and societal levels. In the USA, the detectible cost of work injuries and fatalities is $198.2 billion a year (Michaels, 2014). Consequently, new strategies should be adapted to minimize the contribution of work conditions and injuries to the total expenses. Although the unobserved costs of inappropriate work conditions and work injuries are usually disregarded, they have a significant influence on the total costs and are consequently worth investigating (Dorman, 2000). Work injuries and flawed work conditions increase the stress level among employees, which results in extra costs related to declining co-worker integrity, morality, and virtuous behavior. Likewise, hiring and training new or temporary employees increases the undesirable turn-over rate. Time lost from work, overtime, and the administrative time spent in accident investigations will intensify the overhead costs unnoticeably. The costs of equipment impairment or unsecured products caused by work accidents add further unscheduled obstacles to organizations' overwhelmed budgets. Meanwhile, litigation expenses, legal penalties, citations, interrupted production schedules or any failure to fulfill customer commitments will reduce the competitive edge of the company and have a severe impact on the total revenue (Miller et al., 2002; Aldana, 2001).

## 2. Literature review

To promote less stressful work conditions, understanding the real causes that provoke stress among employees is necessary. Work places with high stress levels reduce employee engagement. Employees become less productive and have higher absence rates than those operating under lower stress conditions. A global survey showed that 90% of staff were disengaged with high stress levels and 57% of those felt absolutely disconnected from their employer. Additionally, the survey conveyed the destructive link between high stress levels and reduced productivity (Dyble, 2014). The

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foundations of stresses at work are numerous and might originate from certain areas that are not immediately visible to management without a good communication structure. Robert (2014) found that 22% of employees in Great Britain accused their financial situation of having a negative impact on their productivity at their workplace. Furthermore, 82% of employer respondents said that helping employees to manage their finances would reduce employee stress levels. In addition, Knauth (1998) addressed the effect of certain characteristics of work schedule on fatigue. Night shifts, early morning shifts, extended working days, and short daily rest periods are among the characteristics that may cause work accidents and reduced productivity. The core concept of reducing risks of fatigue with a shift schedule is to keep it simple. Inconvenient work conditions cause fatigue that reduce the personal ability to think and function well (Wilkinson, 2013). On the other hand, research conducted by Cheese (2010) addressed the fatal combination of fear of losing a job and fatigue that results in rising workers' compensation claims. The study found that the poor economy encouraged organizations to cut their workforce to stay afloat. Accordingly, those who were left to operate the production lines were working prolonged hours and performing duties that were unfamiliar to them without proper training. Statistics show that human errors contribute to up to 80% of industrial accidents. A study on 24/7 industries revealed that a large share of human-error incidents can be attributed to fatigue caused by long work weeks, nighttime work, and repetitive activities, not by equipment or system malfunctions (Carter, 2007). Brecher (2014) addressed the role of management to understand the factors that cause poor job performance among employees. The study showed the impact of work environments on employees' performance, behavior, and motivation.

Previous research focused on the estimation of the cost of work injuries due to unsuitable work conditions using one of three primary methods: the human capital method, the friction method, and the willingness to pay method (Amador-Rodezno, 2005; Behm, 2004; Oxenburgh, 2005). The human capital method suggests that the costs lost in production due to mortality or permanent disability are a multiplication of the prospective discounted earnings by the probability of living to that age. This approach is the most common approach used to estimate the cost of work injuries. However, this approach has two major limitations. First, certain groups are assigned a higher value of impact than others according to their age, gender, etc. The second drawback is the use of full replacement costs independent of whether the worker was replaced or not. The friction cost method has been proposed as an alternative to the human-capital approach of estimating indirect costs. The friction cost method is argued to be based on implausible assumptions not supported by neoclassical economic theory. Furthermore, consistently applying the friction cost method would mean that the method should also be applied in the estimation of direct costs (Johannesson and Karlsson, 1997). Additionally, the friction cost method considers the productivity costs only during the restoration period needed to return to initial production level. This approach covers the cost of short term disability and hiring or training a new employee (Koopmanschap, 1995; Ale, 2008). Determination of the duration period to return to the initial level of productivity is a major shortcoming of this approach (Currie, 2000; Goeree, 1999. The willingness to pay method considers the maximum amount that person would be willing to pay or sacrifice to mitigate or eliminate the probability of injury risk. It measures the monetary difference between the good choice and the bad choice. Usually, this will be conducted by a survey or the additional pay for high risk jobs. The drawback of this method is that the cost will be intensified and overestimated (Rydlewska-Liszkowska, 2005; Hirth, 2000).

## 3. Tangible and intangible costs of a non-ergonomic work place

Obviously, no specific and unique method could monetarily describe the cost of displeasure due to unpleasant work conditions or the cost of pain due to work injuries. Despite the impact of these costs on organizations' performance, these types of costs are usually ignored and mistreated. Accordingly, the costs of work conditions and any subsequent injuries or diseases should be classified as tangible costs and intangible costs. The tangible costs are those that have a common quantity or a tag value attached to cost objects. The costs of equipment repair due to work accidents represent an example of tangible costs (Reville, 2001). Furthermore, the tangible costs can be classified as direct and indirect costs. Reimbursement, compensation, medical invoice, rehabilitation, remedy, wage, and continuation of benefit are examples of direct costs that have close and diametric connections with work injuries (EU-OSHA, 2009; Niven, 2000; Leigh, 1997). On the other hand, indirect costs are the implicit and inevitable expenses that are related to work injuries. Property damage, work interception, rescheduling, administrative costs, rehiring and training, costs of contingency plans, settlements and legal expenses are typical examples of indirect cost of work injuries. The cost object of a direct or indirect cost should be determined to a certain extent without any ambiguity. The sum of both the direct and indirect costs measures the overall cost of work injuries (Weil, 2001). The problem that arises is how to estimate the uncertain intangible costs of work injuries (Mrozek, 2002).

The monetary value of the intangible cost objects related to the level of stress among employees is not well defined. This cost could not be recognized directly during the accounting period. Thus, the intangible costs are insubstantial and can neither be collected within the normal accounting system nor rely on the past or future payments or commitment to pay. The ground of intangible costs is flimsy, and they measure the opportunity that is lost or sacrificed when the choice of action requires an alternative course of action to be given up. The real cost of forgone efficiency or declined performance, lost time due to work accidents, or loss of pleasure are a few examples of intangible costs. Estimating the intangible costs gives a significant judgment about the actual cost of any course of action when there is no explicit accounting system or determinant monetary price attached to the cost objects. Ignoring the intangible cost will result in illusions and false estimations of the true costs that are directly related to the state of work conditions. Based on the tangible and intangible expenses, the cost of inconvenient work conditions and work injuries could be formulated as:

$$C = \sum_{i=1}^{k} T_i + \sum_{j=1}^{m} I \tag{1}$$

where $C$, the total seen and unseen costs; $T$, the tangible costs; $I$, the intangible costs; $k$, the set of all cost objects of tangible costs; $m$, the set of all cost objects of intangible costs.

## 4. The effect of stress on efficiency

Details of the intangible costs of work injuries should be accumulated to describe the entire imperceptible cost objects. For example, suffering due to work injury is a case of input quality variable that relies on but is not limited to other qualitative variables such as the severity of injuries, age, and duration of pain. Based on these descriptions, the intangible cost analysis based on stress level evaluates the employee performance. These evolutions in most cases are qualitative. The intangible costs of work injuries are a function of multiple variables and the relationship between these variables and their values are interpreted and mapped to the input vector. The sum of the individual's deficiency due to work conditions represents the total efficiency of the system. For example, the loss of efficiency shown in Fig. 1 is a function of the severity of injury and the level of experience of the injured person. Normally, this relationship is not linear and could not be generalized. It should reflect the degree of beliefs, the culture of the society, the common laws, and many other factors.

Work conditions and consequent work accidents affect the stress levels among employees. Let ($x$) represent a scaled input qualitative variable such as anxiety, fatigue, work environment, working hours, training level, machine conditions, management–employee engagement, decline in coworker integrity, morality, virtuous behavior, turn-over rate, and time lost from work, which can be surveyed and evaluated based on the Likert Scale. The relationship between these qualitative input variables can be mapped to represent a single value that represents the stress level among employees. Accordingly, the stress can be expressed as the average normalized weight according to:

$$S = \sum_{i=1}^{n} w_i x_i \tag{2}$$

where $S$, stress level; $x_i$, the scaled elements of work conditions that cause stress; $w_i$, normalized weights.

The level of stress among employees due to work conditions directly affects the employee efficiency. Higher levels of stress among employees reduces the efficiency dramatically, as shown in Fig. 2. Usually, the relationship between the stress level and efficiency is not linear. Hence, the affiliation between the stress level and efficiency can be formulized as:

$$\rho = e^{\frac{-S}{m}} \tag{3}$$

where $\rho$, efficiency; $m$, stress scale factor.

## 5. The effect of stress on short term costs

Many stress factors affect the productivity of the production system. Usually, the temporary stress elements will negatively impact employee performance and efficiency in the short term. Hence, the actual amount of labor will drift from the standard level due to the decreased performance level. The stress level affects the total cost of short term tasks due to the decreased production output from the standard level. Therefore, to maintain the output quantity at a certain level, the amount of labor should be increased. This can be done either by hiring extra labor in terms of count or increasing the production schedule time. In both cases, the total cost will increase. Considering the interaction between the amount of labor and capital, the total cost function represents the sum of

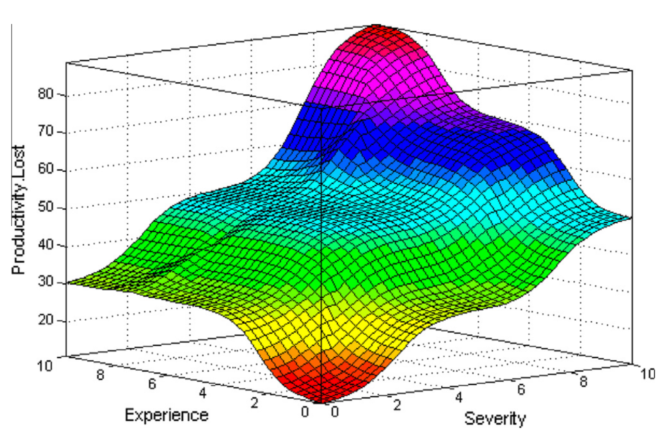


**Fig. 1.** The nonlinear relationship between efficiency, level of experience, and the severity of work injury.

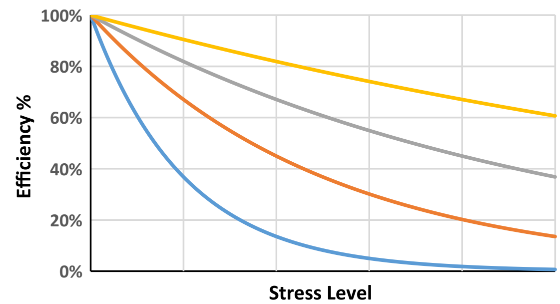


**Fig. 2.** The relationship between stress level and efficiency for different values of $m$.

variable costs that are represented as labor costs and the fixed costs that are represented as capital costs. The objective function will be to minimize the total costs as follows:

$$\text{minimize } TC = \overline{P}_k \overline{K} + \overline{P}_L L_A \tag{4}$$

Subject to

$$Q = A\overline{K}^{\alpha} (\rho L_A)^{\beta} \tag{5}$$

where TC, total cost; $\overline{P}_k$, price per capital unit; $\overline{K}$, capital units; $\overline{P}_L$, price per labor unit; $L_A$, actual labor unit; $Q$, output quantity; $A$, productivity factor.

From an economic point of view, the capital is not substitutable in the short run and is treated as a fixed cost. Meanwhile, the labor can be vary based on the production level. Accordingly, the amount of actual labor to meet a specific demand can be written as:

$$L_A = \left(\frac{Q}{A\overline{K}^{\alpha}}\right)^{\frac{1}{\beta}} e^{s/m} \tag{6}$$

The derivative of Eq. (6) will change the amount of labor with respect to the stress level as:

$$\frac{dL_A}{ds} = \frac{1}{m}\left(\frac{Q}{A\overline{K}^{\alpha}}\right)^{\frac{1}{\beta}} e^{s/m} \tag{7}$$

Substituting Eq. (6) in Eq. (4) yields:

$$TC = \overline{P}_k \overline{K} + \overline{P}_L \left(\frac{Q}{A\overline{K}^{\alpha}}\right)^{\frac{1}{\beta}} \cdot e^{\frac{S}{m}} \tag{8}$$

The change of the total cost with respect to the stress level can be formulated as:

$$\frac{dTC}{dS} = \overline{P}_L \left(\frac{Q}{A\overline{K}^{\alpha}}\right)^{\frac{1}{\beta}} \cdot \frac{1}{m} e^{\frac{S}{m}} = \frac{TC - \overline{P}_k \overline{K}}{m} \tag{9}$$

### 5.1. Illustrative example

$$\text{minimize } TC = 40\overline{K} + 10L_A$$

Subject to

$$100 = 10 \times 4^{1/2} (\rho L_A)^{1/2}$$

In the short run, the capital is fixed at 4 units. The prices of capital and labor are \$40 and \$10, respectively. The efficiency of the production system is assumed to be $\rho = e^{-S/m}$. The demand is 100 units. Based on Eq. (6), the effect of the stress level on the amount of labor is:

$$L_A = 25e^{S/m}$$

The above equation retains its standard design capacity at a minimum amount of labor at zero stress level. As the stress level increases, the amount of labor will increase to keep production at the same level to match the required demand. Accordingly, the increased labor due to the stress level will increase the total cost, as shown in Fig. 3 by:

$$TC = 160 + 250e^{S/m}$$

The change in the amount of labor with respect to the stress level can be calculated as:

$$\frac{dL_A}{dS} = 5e^{S/m}$$

Similarly, the change in the total cost due to increasing the stress level among employees is depicted in Fig. 4 and can be expressed as:

$$\frac{dTC}{dS} = 50e^{S/m}$$

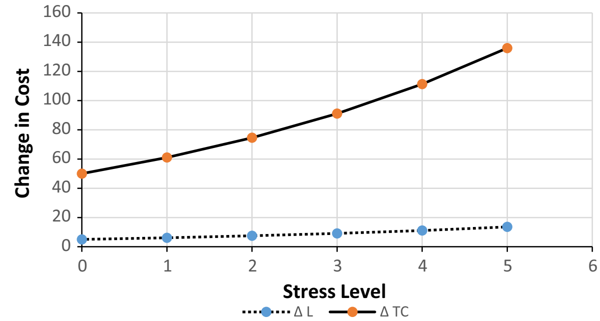


**Fig. 4.** Short term change in total cost and labor with respect to stress ($m = 5$).

## 6. Effect of stress level on the long term costs

Unlike the short term costs, non-ergonomic work conditions and frequent work injuries affect both variable and fixed costs over the long run. Harmful and unmaintained work conditions affect the state of production capital. The frequency of breakdowns, outdated machines, machine malfunctioning, maintenance and repairs, system shutdowns, and the timeworn production structure are influenced by employee performance due to the stress level.

In the long term, the efficiency of labor and capital will be affected by the stress level among employees. From an economic point of view, the unit of capital such as machines can vary over the long run. Let's assume that the labor efficiency is reduced by $\rho$. The actual amount of labor will be $L/\rho$. Accordingly, the stress level will decrease the capital utilization by $K(1-\rho)$ and the actual amount of capital units will be $K(2-\rho)$.

$$\text{minimize } TC = \overline{P}_k K_A + \overline{P}_L L_A \tag{10}$$

Subject to

$$Q = A\left(\frac{K_A}{2-\rho}\right)^{\alpha} (\rho L_A)^{\beta} \tag{11}$$

Setting up the Lagrangian function will result in:

$$l = \overline{P}_k K + \overline{P}_L L_A + \gamma\left(\overline{Q} - A\left(\frac{K_A}{2-\rho}\right)^{\alpha} (\rho L_A)^{\beta}\right) \tag{12}$$

Determine the first order conditions:

$$\frac{\partial l}{\partial K} = \overline{P}_k - \gamma A\alpha \frac{1}{2-\rho}\left(\frac{K_A}{2-\rho}\right)^{\alpha-1} (\rho L_A)^{\beta} = 0 \tag{13}$$

$$\frac{\partial l}{\partial L} = \overline{P}_L - \gamma A\beta\rho\left(\frac{K_A}{2-\rho}\right)^{\alpha} (\rho L_A)^{\beta-1} = 0 \tag{14}$$

$$\frac{\partial l}{\partial \gamma} = \overline{Q} - A\left(\frac{K_A}{2-\rho}\right)^{\alpha} (\rho L_A)^{\beta} = 0 \tag{15}$$

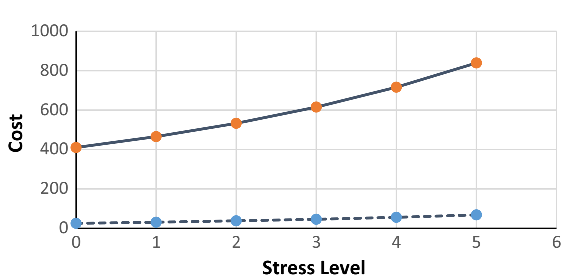


**Fig. 3.** Short term effect of stress on labor and total cost.

Solving the first two first order conditions yields:

$$L_A = \left(\frac{\overline{P}_k}{\overline{P}_L}\right)\left(\frac{\beta}{\alpha}\right) K_A \tag{16}$$

Substituting Eq. (16) into Eq. (15) will result in:

$$K_A = \left[\left(\frac{\overline{Q}}{A}\right)\left(\frac{\overline{P}_L}{\overline{P}_K}\right)^{\beta}\left(\frac{\alpha}{\beta}\right)^{\beta}\right]^{\frac{1}{\alpha+\beta}} (2 - e^{-S/m})^{\frac{\alpha}{\alpha+\beta}} (e^{-S/m})^{\frac{-\beta}{\alpha+\beta}} \tag{17}$$

$$L_A = \left(\frac{\overline{P}_k}{\overline{P}_L}\right)\left(\frac{\beta}{\alpha}\right)\left[\left(\frac{\overline{Q}}{A}\right)\left(\frac{\overline{P}_L}{\overline{P}_K}\right)^{\beta}\left(\frac{\alpha}{\beta}\right)^{\beta}\right]^{\frac{1}{\alpha+\beta}} (2 - e^{-S/m})^{\frac{\alpha}{\alpha+\beta}} (e^{-S/m})^{\frac{-\beta}{\alpha+\beta}} \tag{18}$$

$$TC = \left[\overline{P}_k + \overline{P}_L\left(\frac{\overline{P}_k}{\overline{P}_L}\right)\left(\frac{\beta}{\alpha}\right)\right]\left[\left(\frac{\overline{Q}}{A}\right)\left(\frac{\overline{P}_L}{\overline{P}_K}\right)^{\beta}\left(\frac{\alpha}{\beta}\right)^{\beta}\right]^{\frac{1}{\alpha+\beta}} \times (2 - e^{-S/m})^{\frac{\alpha}{\alpha+\beta}} (e^{-S/m})^{\frac{-\beta}{\alpha+\beta}} \tag{19}$$

Consequently, the change in labor with respect to the stress level will be:

$$\frac{dL_A}{dS} = \frac{1}{m(\alpha+\beta)}\left(\frac{\overline{P}_k}{\overline{P}_L}\right)\left(\frac{\beta}{\alpha}\right)\left[\left(\frac{\overline{Q}}{A}\right)\left(\frac{\overline{P}_L}{\overline{P}_K}\right)^{\beta}\left(\frac{\alpha}{\beta}\right)^{\beta}\right]^{\frac{1}{\alpha+\beta}} \times \left[\beta\left(2 - e^{-\frac{S}{m}}\right)^{\frac{\alpha}{\alpha+\beta}}\left(e^{-\frac{S}{m}}\right)^{\frac{-\beta}{\alpha+\beta}} + \alpha\left(2 - e^{-\frac{S}{m}}\right)^{\frac{-\beta}{\alpha+\beta}}\left(e^{-\frac{S}{m}}\right)^{\frac{\alpha}{\alpha+\beta}}\right] \tag{20}$$

The change in the capital with respect to the stress level will be:

$$\frac{dK_A}{dS} = \frac{1}{m(\alpha+\beta)}\left[\left(\frac{\overline{Q}}{A}\right)\left(\frac{\overline{P}_L}{\overline{P}_K}\right)^{\beta}\left(\frac{\alpha}{\beta}\right)^{\beta}\right]^{\frac{1}{\alpha+\beta}} \times \left[\beta\left(2 - e^{-\frac{S}{m}}\right)^{\frac{\alpha}{\alpha+\beta}}\left(e^{-\frac{S}{m}}\right)^{\frac{-\beta}{\alpha+\beta}} + \alpha\left(2 - e^{-\frac{S}{m}}\right)^{\frac{-\beta}{\alpha+\beta}}\left(e^{-\frac{S}{m}}\right)^{\frac{\alpha}{\alpha+\beta}}\right] \tag{21}$$

The change in the cost with respect to the stress level will be:

$$\frac{dTC}{dS} = \frac{1}{m(\alpha+\beta)}\left[\overline{P}_k + \overline{P}_L\left(\frac{\overline{P}_k}{\overline{P}_L}\right)\left(\frac{\beta}{\alpha}\right)\right]\left[\left(\frac{\overline{Q}}{A}\right)\left(\frac{\overline{P}_L}{\overline{P}_K}\right)^{\beta}\left(\frac{\alpha}{\beta}\right)^{\beta}\right]^{\frac{1}{\alpha+\beta}} \times \left[\beta\left(2 - e^{-\frac{S}{m}}\right)^{\frac{\alpha}{\alpha+\beta}}\left(e^{-\frac{S}{m}}\right)^{\frac{-\beta}{\alpha+\beta}} + \alpha\left(2 - e^{-\frac{S}{m}}\right)^{\frac{-\beta}{\alpha+\beta}}\left(e^{-\frac{S}{m}}\right)^{\frac{\alpha}{\alpha+\beta}}\right] \tag{22}$$

### 6.1. Illustrative example

$$\text{minimize } TC = 40K_A + 10L_A$$

Subject to

$$80 = 10\left(\frac{K_A}{2-\rho}\right)^{0.5} (\rho L_A)^{0.5}$$

The relationship between the amount of labor, capital, total cost, and the stress level can be formalized based on the above equations as:

$$K_A = 4(2 - e^{-S/m})^{0.5}(e^{-S/m})^{-0.5}$$

$$L_A = 16(2 - e^{-S/m})^{0.5}(e^{-S/m})^{-0.5}$$

$$TC = 320(2 - e^{-S/m})^{0.5}(e^{-S/m})^{-0.5}$$

These equations explain the effect of the stress level on the amount of labor and capital to match the required demand. They also reveal the impact on the total cost. Fig. 5 demonstrates this affiliation and shows an increase in the total cost, labor and capital as the stress level increases among employees. The optimum amount of labor, capital, and the companion costs can be achieved at the minimum stress level among work members.

The change in the amount of labor units with respect to the stress level is:

$$\frac{dL_A}{dS} = \frac{8}{m}\left[\left(2 - e^{-\frac{S}{m}}\right)^{0.5}\left(e^{-\frac{S}{m}}\right)^{-0.5} + \left(2 - e^{-\frac{S}{m}}\right)^{-0.5}\left(e^{-\frac{S}{m}}\right)^{0.5}\right]$$

The change in capital with respect to the stress level is:

$$\frac{dK_A}{dS} = \frac{2}{m}\left[\left(2 - e^{-\frac{S}{m}}\right)^{0.5}\left(e^{-\frac{S}{m}}\right)^{-0.5} + \left(2 - e^{-\frac{S}{m}}\right)^{-0.5}\left(e^{-\frac{S}{m}}\right)^{0.5}\right]$$

The change in cost with respect to the stress level is:

$$\frac{dTC}{dS} = \frac{160}{m}\left[\left(2 - e^{-\frac{S}{m}}\right)^{0.5}\left(e^{-\frac{S}{m}}\right)^{-0.5} + \left(2 - e^{-\frac{S}{m}}\right)^{-0.5}\left(e^{-\frac{S}{m}}\right)^{0.5}\right]$$

Fig. 6 indicates the exponential impact of changing the stress level on the labor and capital. It also shows the amount of intangible costs related to deviation of the stress level between employees related to the state of the ergonomic work place level.

## 7. Effect of stress level on the cost–volume–profit

Over the long run, the fixed costs will increase due to increasing stress level by $\Delta F = F(1 - \rho)$. At the same time, the stress will increase the variable cost by $\Delta V = V\left(\frac{1-\rho}{\rho}\right)$. Accordingly, the relationship between the total cost and the level of stress can be written as:

$$TC = F\left(2 - e^{-\frac{S}{m}}\right) + QU_c\frac{1}{e^{-S/m}} \tag{23}$$

The cost–volume–profit relationship will be related to the stress level according to:

$$\text{Profit} = QU_s - F(2 - e^{-S/m}) - QU_c\frac{1}{e^{-S/m}} \tag{24}$$

At a zero stress level, Eqs. (23) and (24) retain their formal shape. Consequently, the breakeven point will vary based on the stress level according to:

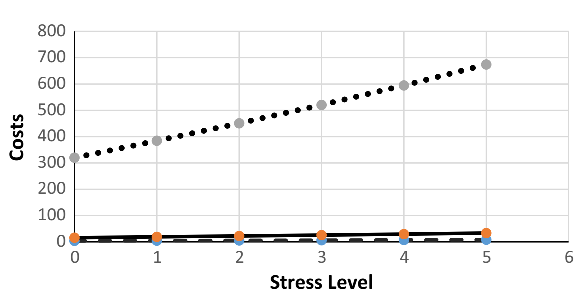


**Fig. 5.** Actual capital, actual labor, and total costs versus stress level in the long term.

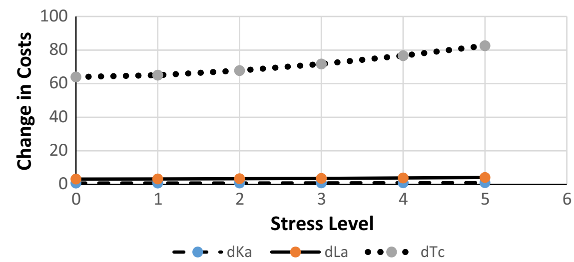


**Fig. 6.** Long term change in labor, capital, and total cost versus stress.

$$Q^* = \frac{F(2 - e^{-S/m})}{U_s - \frac{U_c}{e^{-S/m}}} \tag{25}$$

To achieve and reach a breakeven quantity, the denominator in Eq. (25) should be greater than zero:

$$U_s - \frac{U_c}{e^{-S/m}} > 0 \tag{26}$$

which yields:

$$S < -m \ln\left(\frac{U_c}{U_s}\right) \tag{27}$$

The last inequality indicates that the stress represents the chaotic state on the system, which reflects the amount of disorder in the dynamic production system. Therefore, the maximum allowable elongated stress due to the work environment can be interpreted as the degree of disorder of the system.

### 7.1. Illustrative example

Consider a production system with a price per unit of \$15, a variable cost per unit of \$7, and a total fixed cost of \$9000. Based on Eq. (27), the allowable stress level among employees should not exceed:

$$S < -m \ln\left(\frac{7}{15}\right) = 0.76 \text{ m}$$

The relationship between the breakeven quantity and the allowed stress level can be formulated as:

$$Q^* = \frac{9000(2 - e^{-S/m})}{15 - 7e^{S/m}}$$

Fig. 7 shows the standard breakeven quantity at zero stress level. This quantity is amplified significantly as the stress level approaches the maximum allowable stress. The breakeven quantity will never be reached when the stress level exceeds the maximum allowable level. The increasing stress level will increase the amount of labor and capital, which in return will increase the total cost of production significantly.

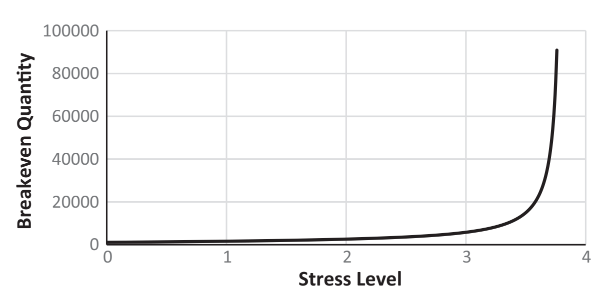


**Fig. 7.** Breakeven quantity versus stress level.

## 8. Conclusions

This study demonstrates the effect of work conditions and related work injuries on the level of stress among employees. Unappropriated work conditions will amplify the stress level among employees, which will significantly influence the production system productivity. On the other hand, a more ergonomic work place and safer practices will benefit corporations in numerous ways. As mentioned previously, the intangible costs are insubstantial, and they measure the opportunity that is lost or sacrificed. Usually, these costs are not estimated and are ignored. This research addressed the link between the intangible costs and the stress levels among employees over the short term and the long term. The equations addressed the increased amount of invested capital and labor due to the increased stress level. This increase will affect the total cost over both the short run and the long run. An improvised work place will create chaos that represents the amount of production system disorder. The proven resilient relationship between the level of production system disorder and the encountered stress level assure the importance of enhancing the work conditions to make a profit. The breakeven quantity is highly sensitive to the employee's performance, and this research shows that under harsh work conditions, the breakeven quantity might be unattainable. Sources of disorder are numerous in any service or manufacturing facility, and these sources prevent any manufacturing system from reaching 100% efficiency. Therefore, the elements that aggravate stress among employees should be eliminated or reduced. Management's efforts should be oriented toward a more ergonomic, safer, and more pleasant work environment to sustain an optimum level of productivity. This research illustrates the unseen economic impact of stress levels among employees in terms of hidden costs that are impeded in the production process due to the state of work conditions over the short run and the long run.

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