Safety in the Workplace and Its Impact on Labor Productivity: An Explanatory Study in the Furniture Industry

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Abstract

In a furniture manufacturing factory, workplace safety is crucial in reducing accidents, minimizing losses due to downtime, and increasing productivity. This research paper evaluates the prevailing safety conditions and their impact on individual labor productivity. Two questionnaires were designed to collect data for both laborers and management. Productivity was measured using Kurosawa's method, and safety conditions were measured to determine their relationship. An excellent Pearson correlation coefficient of 0.94 explained a strong dependence between safety and productivity. Further, a machine learning model predicted that for every 10% improvement in safety, productivity was likely to increase by about 34.89%. Safety improvement recommendations were thus provided to increase productivity by that margin.

Keywords: Workplace safety, Labor productivity, Kurosawa approach, Human factor, Machine learning

1. Introduction.

Today's manufacturing industries are characterized by increasing production, which requires optimal efficiency to meet demand. However, this chase for efficiency can be discounted significantly due to unfortunate accidents occurring at any time, which eventually lead to the loss of human life and capital. Safety measures are very critical to deal with these uncertainties. The collaboration between top management and employees can play a significant role in making this possible. As a result, employees have a critical role in following proper safety protocols and avoiding uncertainty, as a single unawareness can have catastrophic consequences. Safety encompasses two related factors: the health and well-being of employees and the working environment. Ensuring the safety of both is instrumental to preventing accidents and promoting a sustainable manufacturing process [1]. High productivity is the primary objective of any manufacturing industry, as productivity reflects the amount of capital invested and the corresponding profit generated [2]. This paper investigates the relation between workplace safety and its impact on productivity. The productivity of an organization largely depends on two main factors. External factors are uncontrollable, and internal factors can be controlled [3]. In this paper, safety is considered as an internal factor to productivity. One of the primary objectives of this paper is to start an initiative to check the safety level in the furniture manufacturing industry in Bangladesh. In recent years, the manufacturing sector has been plagued by catastrophic accidents, resulting in significant loss of life and economic losses. The collapse of the Rana Plaza in 2013, which claimed 1129 lives [4], is a stark reminder of the devastating consequences of inadequate safety measures. Similarly, the fire at Tazreen Fashions Factory [5] and the boiler explosion at Tampaco Foils Ltd. [6] resulted in the loss of 112 and 24 lives, respectively. These tragic incidents testify to the urgent need for improved safety standards in manufacturing plants. The economic implications of these accidents are equally severe. The suspension of the Generalized System of Preferences (GSP) by the United States of America in 2013 [7] and the warning issued by the European Union to suspend GSP if safety standards are not improved [8] are clear indications of the economic costs of neglecting workplace safety. The loss of GSP affects the country's economy and has far-reaching consequences for the manufacturing sector as a whole. Implementing robust safety standards in the workplace can transformatively impact various aspects of organizational performance. By prioritizing safety, organizations can reduce the incidence of accidents and equipment breakdowns and minimize risks to workers' health and well-being. Moreover, a safe working environment can positively impact labor productivity, ultimately benefiting the organization and the country financially. The primary objectives of this paper are twofold. Firstly, it seeks to investigate the relationship between safety and labor productivity, examining how safety standards influence employee productivity using a machine learning model to predict productivity by increasing safety. Secondly, it aims to identify critical factors that can improve safety conditions and, in turn, enhance labor productivity. By exploring these vital issues, this study hopes to provide valuable insights for organizations seeking to optimize their safety protocols and boost productivity.

2. Methodology.

Labor productivity can be evaluated through various methods. This study focuses on assessing labor productivity in the Furniture industry, employing the structural approach developed by Dr. Kazukiyo Kurosawa [9]. Notably, Dr. Kurosawa has extensive experience in productivity research, having undertaken several assignments for prominent organizations such as the International Labor Organization and the Asian Productivity Organization. His seminal work, published in 1980, provides a foundation for this research [Kurosawa, 1980].

$$Productivity\ of\ Worker = \frac{\text{Output}}{Input\ of\ worker's\ effort} \qquad [1]$$

This formula is for a single worker. The structure of work hours on which productivity measurement is based on the Kurosawa approach is shown below.

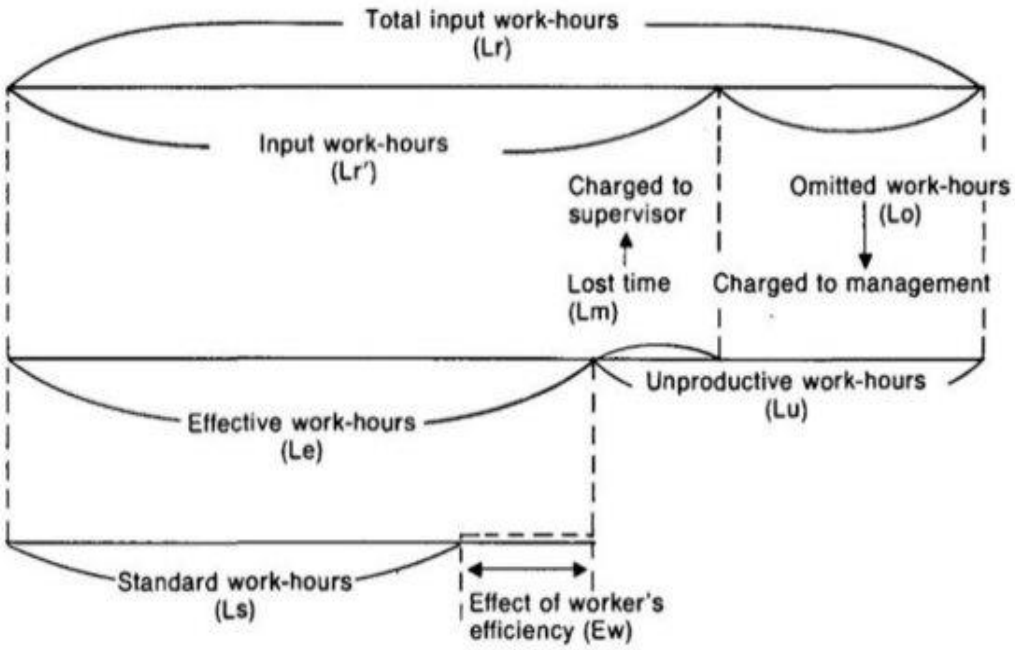


Figure 1:.Structure of work hours in Kurosawa approach [9]

Total input work hours comprise regular work time and overtime per day minus omitted work hours, which include scheduled breaks such as lunch breaks. Lost time, which is the responsibility of the appointed supervisor, encompasses various interruptions, including Time spent receiving instructions from the supervisor, Prayer breaks, miscellaneous breaks (e.g., drinking water, tea breaks, gossiping)

The overall productivity of a worker can be calculated using the equation proposed by Kurosawa (1980).

$$T = \frac{Q}{L} \qquad [2]$$

T is the overall employee productivity, Q is the total output, and L is the total input work hours. This study aimed to investigate the relationship between workplace safety and individual productivity. A self-administered questionnaire was used to collect data from 400 workers. The questionnaire consisted of two sections - **Section 1: Demographic Information** (Basic information about the workers, including Gender, Age, and Experience) and **Section 2: Workplace Safety Conditions (**Questions assessing the safety conditions of the workplace from the individual employee's perspective, including Adequacy of safety equipment, Proper safety protocols, Safety signs, Training of personnel, Conducting safety drills, Proper insulation, Proper Work Posture, Workstation design, Proper ventilation, Adequate first aid and ambulance service)Responses were marked using a 5-point Liker scale, where five means strongly agree, highly adequate, or similar response 1 means Strongly disagree, highly inadequate, or similar responses. The overall summation of the responses from all questions was calculated to assign an individual score on the safety condition. The safety scores were then compared with individual productivity scores using a fitted line plot and regression analysis using Python.

3. Data Analysis and Results.

The basic information of the workers is summarized in the following table:

Table 1: Summary of workers' basic information

No. of workers interviewed	400
Male Workers	300
Female Workers	100
Age	Minimum 18,Maximum45 1. 18-24 (41.47%) 2. 25-30 (29.49%) 3. 31-36 (22.58%) 4. 37-42 (6.46%)
Work Experience	Minimum 0 years, Maximum 20 years 1. 0-5(11.37%) 2. 6-10(35.49%) 3. 11-15 (39.51%) 4. 16-20 (13.63%)

Employee productivity was calculated using equation (2). Regular time and overtime were added to get the total input work hour Lr. Omitted work hours (lunch break): Lo was one hour and was constant for all employees. Lost time Lm consisted of time for instruction from the supervisor, tea break, drinking water, gossiping, using the toilet, etc. The output for each employee was calculated using the following equation: $Q = (Ot * OO) + (RO * 7) - (Lm * (RO + OO\ 2))$ (3) Where Q is the output, Ot is overtime, OO is overtime output, RO is regular output, and Lm is lost time. 4 The output values from equation (3) and the total input work hours (Lr) were used in equation (2) to calculate the overall productivity of the workers.

The safety scores were calculated based on the responses from the questionnaire. The possible ranges of scores were:



Figure 2: Safety score range and safety condition

The summary of the safety score and productivity of the existing system is given below in Table 2

Table 2: Summary of Safety Score and Productivity

	existing safety	existing productivity
Minimum	28	800
Maximum	37.27924155	1900
Average	31.07919409	1393.288473
Std	1.806793541	299.6273064

From the summary (Table 2), it can be concluded that based on the range of safety determined by this paper, the current safety status of the factory is Moderate Safety. The fitted line plot of productivity and safety for the 400 workers interviewed is shown below in Figures 3 and 4:

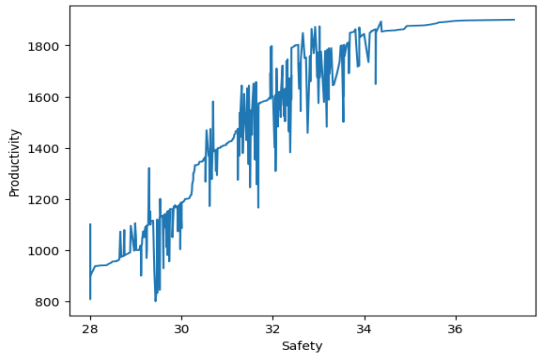


Figure 3: Safety vs. Productivity

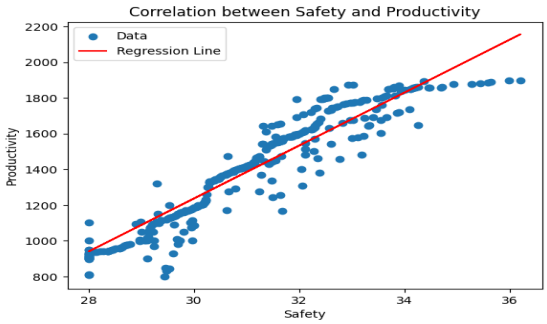


Figure 4: Correlation between Safety and Productivity

Statistical analysis (Table: 3b) of the datasets shows a value of less than 0.05 and a Pearson correlation coefficient (r) value close to 1, which suggests a strong correlation between safety and productivity. From the regression analysis (Table: 3a), we trained our model in Python and generated a dataset of increased safety scores, and from the linear regression, we got the predicted productivity value. For regression analysis, the model was trained using the existing data set (Safety, Productivity) of 400 workers. The test size was 0.8, and the random state was 42.

Table 3: Statistical (3b) and Regression (3a) Analysis

Regression parameter	Value
Slope	148.0917172
Intercept	-3205.913173
Regression line equation:	y = 148.09x + -3205.91
Y (Dependent Variable)	Productivity
X (Independent Variable)	Safety

(3a)

Statistical Analysis	
Metrics	**Values**
Pearson_r	0.945403839
N	400
Degrees of freedom	398
t_Value	2.742513582
P Value	0.006332406
Null Hypothesis	Rejected

(3b)

The comparison of the existing and predicted productivity is analyzed. The results are shown in Fig: 5. It shows a significant improvement in the average productivity (34.89%), which portrays the direct effect of the safety score on productivity and also indicates that by increasing only 10% safety measures the average productivity value can raise to 1879.37 taka per hour.

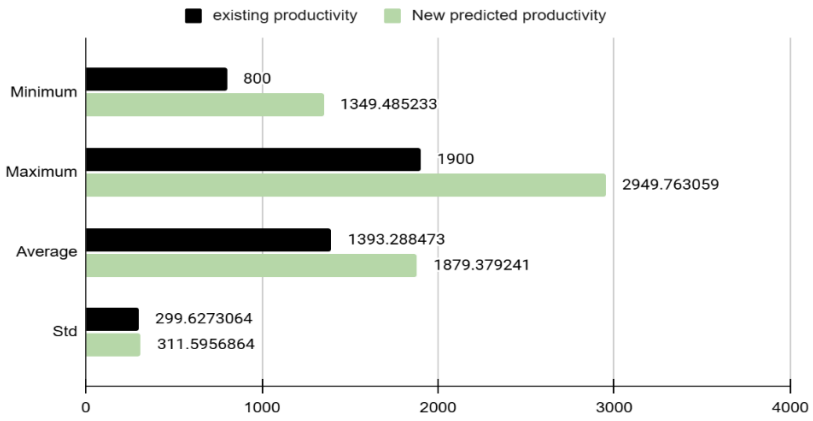


Figure 5: Productivity comparison

4. Discussion.

Data analysis shows a strong correlation between safety and productivity, although the safety score of the current workers could be better. Some workers are very experienced and highly productive, but they must be more conscious about safety. The analytics also show that if safety is increased by 10%, productivity will rise by more than 34%. Safety measures and drills are necessary in the furniture industry where the products are heavy and complex manufacturing operations are involved. We further observed the workers concerning some key factors to determine the root cause for the mediocre safety range.

Table 4: Key factors identifying to improve safety

Safety improvement metrics [12]	Scale	No of workers	Average score	Safety improvement metrics[13]	Scale	No of workers	Average score
Working posture	**<=1**	**70**	**2.7325**	**Safety drills**	**<=1**	**135**	**2.405**
	<= 2	**118**			**<= 2**	**79**	
	<=3	**98**			**<=3**	**80**	
	<=4	**77**			**<=4**	**101**	
	<=5	**37**			**<=5**	**5**	
Workplace design	**<=1**	**85**	**2.3175**	**Preventive maintenance**	**<=1**	**199**	**1.89**
	<= 2	**165**			**<= 2**	**92**	
	<=3	**99**			**<=3**	**65**	
	<=4	**40**			**<=4**	**42**	
	<=5	**11**			**<=5**	**2**	

The safety score can be improved by following some possible steps.

1. Workers in the sanding unit should always use masks and hand tools.
2. Chemical section officers and workers should be more careful and receive the necessary training.
3. Fire safety should be introduced strictly, and fire safety equipment should be checked regularly.
4. Workstations and machine height should be adjusted to maintain good posture.
5. Heavy machinery should be kept under preventive maintenance, and those machines that create extreme noise and vibration should be replaced.
6. Management concern and commitment are also necessary to improve the safety conditions.

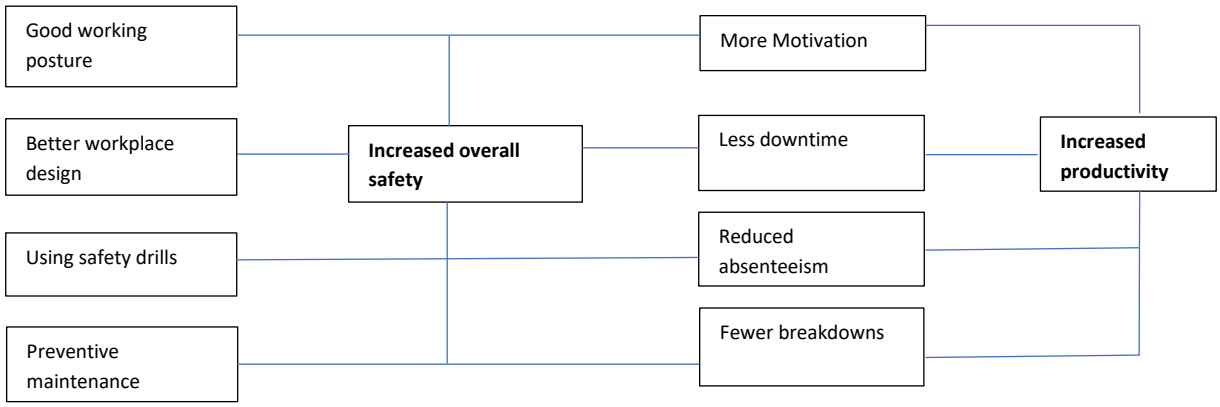


Figure 5: Interconnection between safety improvements and productivity

When a workplace isn't safe, it can significantly impact employees' productivity. If machinery breaks down or safety equipment is lacking, accidents can happen, and employees can get hurt. This means that work hours are wasted, and productivity suffers. When employees are injured, they need to take time off, which can cause problems on the production floor, like uneven workloads and bottlenecks. So, it's essential to prevent accidents and ensure the workplace is safe, which will help reduce wasted time and boost productivity.

5. Conclusion.

This project provides for the enhancement of safety facilities because it seeks to eliminate the chances of loss of human life. Management is usually faced with this safety problem, but with proper layout and adherence to safety standards, accidents can be minimized. The research results highlight a significant and positive linear relationship between the safety and productivity of employees working in the factory. Valid expenses for more safety features should be undertaken, particularly those protecting life and capital while enhancing output. Applications and suggestions that supported improving safety and productivity, respectively, were made based on the employees' perceptions. Future research may use these results and undertake the necessary reforms as suggested in the practice recommendations. This study is limited in that it depended on employee assumptions to calculate the time lost, and more limitations could have been due to a lack of time and resources.

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