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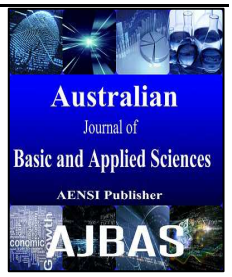

Effects of Ergonomic Risk Factors on Production Error in Manufacturing Firms

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ABSTRACT

Background: Production error in manufacturing firms can be a serious issue which leads to profit loss and product liability. Although manufacturers have started to look into ways to enhance their productivity, many still appear to be unable to produce successful and convincing results. **Objective:** This study aims to examine the significance of the effects of ergonomic risk factors (mental workload, repetition, environment condition and machinery) on production error in manufacturing firms. **Results:** After a collection of 252 survey responses, the data was analysed using descriptive, reliability and multiple linear regression analyses via SPSS version 21. It was found that ergonomic risk factors have significant effects on production error. It was also discovered that 53.4% of the variance in production error was explained by mental workload, repetition, physical environment and machinery. **Conclusion:** This study is useful for manufacturing workers, supervisors and engineering managers as a precursory guideline to help identify the potential causes of production error, with an eventual purpose of reducing the cost of production in manufacturing firms.

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INTRODUCTION

The term 'error' should not be taken lightly in manufacturing firms as its impacts involve loss of money to the manufacturers. In view of this, manufacturers have started to monitor their workers' performance by empowering employees with training and seminars to ensure employees are up to date with the working lifestyle and skills of the company.

However, having to put quality labours in practice, some manufacturers are still not able to achieve considerable improvements in production. Yeow and Sen (2002) pointed out that the workplace in Malaysia, namely manufacturing firms, lack of proper ergonomics guidelines, training and procedures.

Ergonomics can be defined as factors that brings out information on human behaviour, tasks, environment, safety and comfort for working individuals (Chapanis, 1985). It involves a complex relationship between workers and their jobs tasks (Rowan and Wright, 1995).

Majority of Malaysia's manufacturers appear to be unaware of the ergonomic risk factors that can potentially introduce significant negative impacts in productivity. Black (1999) stated that workplaces which are not ergonomically designed can cause production errors and these errors are considered as a form of wastage or loss of money.

Therefore, there is a dire need to examine the effects of ergonomic risk factors on production error in manufacturing firms in order to confirm their importance to the manufacturing industry.

Manufacturing firms in Malaysia have grown dramatically since the year 2000 (Fathi *et al*., 2009). Besides that, this industry also created more than 1.9 million employments in 2008 (Fathi *et al*., 2009). According to Karim *et al*. (2008), Malaysia is one of the world's leading manufacturer and exporter of semiconductor devices.

However, the rapid development of employment and exporting in manufacturing sectors could also mean that there is an immense risk in terms of workplace problems such as human errors and accidents. It appears that the awareness level on ergonomics issues related to manufacturing workplaces in Malaysia is still low (Yeow and Sen, 2002).

Well established ergonomics concepts have the tendency to improve the quality of large productions. For example, the Toyota Production System was strengthened by the top management due to the workers' commitment and improvement in ergonomics concepts which contributed to

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production efficiency and quality (Adler *et al*., 1997).

Thun *et al*. (2011) also concurred that improving the concept of ergonomics can help reduce production error and enhance a company's productivity. Ergonomics also helps provide relief to workers in uncomfortable, life-threatening or hazardous situations in the workplace.

The preceding substantiations justify the importance of enhancing the knowledge on ergonomics among workers. With improved knowledge and awareness on ergonomics, potential errors during production can be avoided. Hence, it is essential to understand the effects of ergonomic risk factors on production error in manufacturing firms.

Ergonomic Risk Factors:

Mental Workload:

Mental workload refers to a portion of works stress developed to meet the cognitive task demands of the workplace (DiDomenico and Nussbaum, 2008). Research shows that mental workload could significantly correlate with production errors in manufacturing firms (Layer *et al*., 2009).

In a complex task within a workplace, operators may have to increase their work routines by contributing additional mental effort to sustain their performances, which can cause the tendency to make mistakes higher than usual (Yeow *et al*., 2012).

Thus, it is believed that all these complex job tasks can affect the performance of workers since they are more prone to errors. Hence, this study proposes the following hypothesis:

H1: Mental workload significantly affects production error in manufacturing firms.

Repetition:

Repetition can be defined as excessively repeated activities in short and monotonous job cycles, with close exertion patterns (Kilbom, 1994). Manufacturing work is one of the few examples of monotonous based jobs which are highly exposed to repetitive stimulation. Workers who perform repetitive jobs are faced with risks that affect them mentally and physically (Pinzke and Kopp, 2001).

Repetitive jobs can also lead to error in manufacturing firms (Yeow *et al*., 2014). Since most studies also concluded that a continuously long cycle of repetitive work can lead to high production error, it is therefore rational to propose the following hypothesis:

H2: Repetition significantly affects production error in manufacturing firms.

Physical Environment:

Ergonomic risk factors such as the physical environment can also significantly affect errors in manufacturing firms (Yeow *et al*., 2014). A poor physical environment can decrease a worker's concentration and productivity in the tasks he/she is given (DiNubile and Sherman, 1999). The environment becomes unpleasant when workers tend to put forth lesser effort in their production activities (Campbell, 1999).

A study concluded that the assembly workers in a Malaysian manufacturing firm worked in an environment with many disconcerting factors, such as the excessive noise, heat, vibrations and life-threatening hazards in the machine operations (Yeow *et al*., 2014). Work performance can directly be affected by the environment condition depending on how exposed an individual is towards the harsh environment (Bhagat, 1983). Hence, the following hypothesis is proposed:

H3: Physical environment significantly affects production error in manufacturing firms.

Machinery:

In the manufacturing sector, machinery and tools play a significant role in daily manual work. Machinery relies on manual power for its operation and is designed to be primarily supported by the hand. Yeow *et al*. (2014) revealed that manufacturing firms are complex organisations that require a lot of human-machine interaction.

Hence, any mishandling of manual tools or machines can lead to accidents and production errors. Furthermore, most of the workplace machine designs are fit for the capacity of a male worker. There are also many hand tools and machines that favour right-handed individuals. Based on the preceding justifications, the following hypothesis is proposed:

H4: Machinery significantly affects production error in manufacturing firms.

Methodology:

For this study the dependent variable is production error while the other 4 independent variables include mental workload, repetition, physical environment and machinery. A total of 252 questionnaires are randomly distributed to the manufacturing workers, supervisors and engineering managers of several manufacturing firms in Malaysia.

This study focused on three main states in Malaysia, namely Penang, Selangor and Kuala Lumpur. The 5-point Likert scale is adopted for the questionnaire development and the data are analysed and interpreted using Statistical Package for Social Sciences (SPSS) version 21. The analyses used are descriptive, reliability and multiple linear regression analyses.

RESULTS AND DISCUSSION

From the survey results, there are a total of 188 male respondents (75.2%) and 64 female respondents (24.8%). Majority of the respondents are around 25 to 29 years old (38.8%), followed by the age range of 30 to 34 years old (33.6%). It appears that 12% of the respondents are aged below 24 years old and 9.6% of them are aged 35 to 40 years old.

Lastly, 6% of the respondents are above 40 years old. There are 243 respondents of Malaysian nationality (97.2%) and only 7 respondents are foreigners (2.8%). The survey covered 3 geographical areas in Malaysia, namely Selangor (42.8%), Kuala Lumpur (36.8%) and Penang (20.4%).

Table 1 shows the Cronbach's alpha reliability results for both the dependent and independent variables. The Cronbach's alpha values appear to range from 0.799 to 0.909, which means that all the values are acceptable as they are above the alpha value of 0.7. The highest alpha value is exhibited by the repetition variable (0.909) whereas the machinery variable presented the lowest alpha value (0.799). The alpha value for the dependent variable (production error) is 0.906 which also an acceptable value. Hence, the internal consistency of the questionnaire items in this study is considered reliable and acceptable for further analyses.

Table 2 presents the multiple linear regression analysis on the effects of ergonomic risk factors on production error, where the *p*-value for mental workload, repetition, physical environment and machinery are all below 0.05. A *p*-value which is lower than 0.05 would indicate that the effect of the predictor on the dependent variable is significant. Hence, the results conclude that *H1*,*H2*, *H3* and *H4* are not rejected.

Table 3 shows the coefficient of determination (R^2). The R^2 value is 0.534, indicating that 53.4% of the variance in production error is explained by mental workload, repetition, physical environment and machinery.

From the analysed results, it is clearly shown that the effects of all the ergonomic risk factors on production error are significant. The overall correlation between these ergonomic risk factors and production error is also high (R = 0.731). In agreement with previous studies, mental stress in the workplace can lead to poor concentration and performance (Yeow *et al*., 2012). Manufacturing workers who normally perform monotonous jobs over long periods of time with little or no breaks are often prone to fatigue. These workers are at risk in allowing errors in production to go undetected.

The physical environment can also significantly affect production error. If the workplace is too noisy, hot or cold, workers can easily lost their concentration at work. Consequently, mistakes happen and productivity decreases, along with the risk of workers being exposed to injuries.

Machinery with poor ergonomics features tends to increase production error. Decreased usability in machines may cause workers to commit functional and handling errors since their designs are not user-friendly or ergonomic.

Table 1: Cronbach's Alpha Reliability Results

Variable Item	No. of Items	Cronbach's Alpha
Mental Workload	5	0.865
Repetition	5	0.909
Physical Environment	5	0.863
Machinery	5	0.799
Production error	4	0.906

Table 2: Multiple Linear Regression Analysis (Ergonomic Risk Factors - Production Error)

	Unstandardised Coefficients			
Variables	*B*	Std. error	*T*	Sig.
(Constant)	0.53	0.385	1.377	0.171
Mental workload	0.223	0.068	3.301	0.001
Repetition	0.220	0.063	3.508	0.001
Environment Condition	0.212	0.071	2.980	0.003
Machinery	0.372	0.07	5.339	0.000

Table 3: Coefficient of determination results

Model	*R*	R^2	Adjusted R^2
1	0.731	0.534	0.521

Conclusion:

With all the supporting evidence and analyses, the objective of this study has been achieved. The outcome can be useful for manufacturing workers, supervisors and even managers as they can develop preliminary guidelines to potentially identify the ergonomic risk factors that affect their workers and productivity. In regard to directions for future research, it is suggested that researchers widen the coverage of the studied area to include more states or regions, since this study only concentrated on three major states in Malaysia. Besides that, other methods of data collection can be administered to identify the causes of production error. For instance, qualitative research techniques such as interviews, focus groups and video recordings can be administered to enrich the quality of the data and improve the research on production errors and ergonomics issues.

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