Optimizing production cost using ergonomic data

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1. Introduction

This paper presents a case study application of a novel Operations Research (OR) approach to forecasting production system level financial performance using Human Factors (HF). OR models rarely include HF aspects in predicting financial outcomes, which may lead to overestimating the profitability of the system. They usually assign a fixed value to employee performance and do not investigate Work-related ill health (WIH) risk factors and their financial and operational consequences when forecasting financial results.

2. Methods

We demonstrate a hierarchical, 3-level approach with worker, workstation, and system level sub-models). At the individual level; workers are assumed to have three health states: healthy, in-pain but at work (presenteeism), or injured and absent - in which case a replacement worker is assumed and claim costs are added. Individual health states are predicted over time based on the quantified physical risk factor exposures and risk ratios obtained from epidemiological studies. A Markovian modelling method was used to determine the probability of an employee being in each of the possible health states in a given period. At the 'Workstation Level' the productivity and quality of an operator will depend on their health state, as well as the design of the workstation itself. Here conventional production economic costs are included such as the cost of the materials, labour time, overhead costs. Each worksation's performance is passed on to the 'System Level' model which accounts for the configuration of workstations including aspects like bottlenecks. Then a mathematical model was developed for the production system to replicate its production behavior and incurred total cost. This system level mathematical model was optimised to calculate the best-case (lowest) total production cost and production profile for the system based on in-data provided.

We present a proof of principle demonstration based on a seven workstation auto parts production facility. Seven physical risk factors for WIH of the shoulder and back were quantified in the field for each workstation. Since this system had no recent sickness absence reports the resulting model had only normal and presenteeism health staes. Optimal production costs were estimated without HF (providing a referent index at 100) and with HF WIH effects. A one-factor analysis was conducted examining the effects of varying a cumulative spine load in a single station – the system bottleneck which also had the highest measured workload. Production volume was held constant in all models.

3. Results

When all seven risk factors were considered at their quantified levels the total cost of production was 1.23% greater then when the costs were calculated without including HF effects. Figure 1 illustrated the effects of varying the single Cumulative Spinal Load risk factor for the bottleneck workstation. This showed that the underestimation of costs, compared to non-HF assessement, could be as low as 0.7% and as high as 1.5% extra as this single risk factor was changed. For comparison, the observed cumulative compression as quantified was 20.6 Mega Newton seconds per full time shift (MNs/shift) – the mid point on Figure 1. The calculated cost was aligned with the historical data of the facility according to managers of the facility.

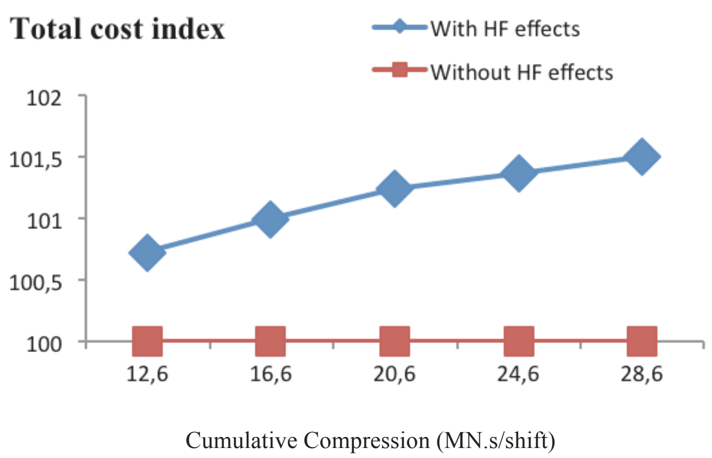

Figure 1: Total cost index change versus cumulative compression level variations in a single workstation while all other risk factors are kept constant

4. Discussion and Conclusions

This study has demonstrated the feasibility of predicting total production costs based on conventional economic data supplemented with WIH risk factor data that can be quantified in the field. This is a unique capability as conventional economic models usually ignore HF aspects and health economic models do not account for system level production costs. Furthermore this system allows potential improvements in HF to be evaluated in terms of total production costs for the system.

In this particular case, there were no recent lost time accidents so the impact of HF in economic terms was limited to presenteeism effects. While it is technically possible to include changes in quality levels, we were unable to isolate the human factors related fraction of quality deficits in the system in this case Furthermore the available research quantifying the mathematical relations between HF and production quality is sparse. Future work must focus on broadening the application of the technique to more sites as well as followup studies to examine the actual financial costs incurred by the company. While validity concerns remain, this technique may provide a valuable tool to help managers understand the impact of poor HF in terms of the performance of the company.

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