

The Effects of Worker Learning, Forgetting, and Heterogeneity on Assembly Line Productivity

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The authors investigate through several simulations how patterns of learning and forgetting affect the operating performance of an assembly line. A unique aspect of this study is that a distribution of learning/forgetting behavior based on an empirical population of workers is used rather than assuming the same learning pattern for all employees. The paper demonstrates that modeling only central tendency and not the variations across workers tends to systematically underestimate overall productivity. The data used to estimate the parameters for the distribution of learning curves were collected from an assembly line that produces car radios.

Analysis of the models fit to a population of workers reveals that higher levels of previous experience are positively correlated with higher steady-state productivity levels and negatively correlated with the learning rate. To further motivate the study, a conceptual model with several factors hypothesized to influence assembly line productivity is presented. Among key factors included in the model are the rate of worker learning, the size of the worker pool, task tenure, and the magnitude of worker forgetting. In controlled computer simulation experiments, each of these factors was found to be statistically significant, as were a number of the two-way interaction terms.

(Learning; Forgetting; Worker Heterogeneity; Simulation)

1. Introduction

A variety of forces are simultaneously creating a new learning environment for shop floor workers. For example, many organizations are shifting from making a few products with long life cycles to managing product families with shrinking life cycles. At the same time, many of these organizations are accelerating their rate of process innovation and improvement, increasing worker flexibility through cross-training, and restructuring or reorganizing work activities. An important implication is that in this new

environment, the individual worker must constantly adapt to changing tasks.

Furthermore, as the frequency with which individual workers are required to master new tasks increases, the amount of time the workforce spends on the steep part of the learning curve increases as new products are introduced, as they are rotated to other jobs, and as their work is restructured (e.g., Uzumeri and Nembhard 1998, Uzumeri and Sanderson 1995, Brown and Duguid 1991). More specifically, in less dynamic environments workers have ample

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 $2 \text{ CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g}) + \text{C}_2\text{H}_2(\text{g}) \rightarrow 2 \text{O}_2(\text{g}) + \text{C}_2\text{H}_2(\text{g}) + 2 \text{H}_2(\text{g}) + \text{C}_2\text{H}_6(\text{g})$ $\Delta h = 94.5 \text{ kJ}$
 $\text{H}_2\text{O}(\text{g}) + \text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g})$ $\Delta h = 71.2 \text{ kJ}$
 $\text{C}_2\text{H}_6(\text{g}) + \frac{7}{2} \text{O}_2(\text{g}) \rightarrow 2 \text{CO}_2(\text{g}) + 3 \text{H}_2\text{O}(\text{g})$ $\Delta h = -1560 \text{ kJ}$

co₂ g 3 h₂ o g Δh 283 kj g 1 c₂h₆ g

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