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# SHIFTING PRODUCTION BOTTLENECKS: CAUSES, CURES, AND CONUNDRUMS*

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We examine the phenomenon of shifting production bottlenecks from an analytic perspective. We quantify the propensity of a work center to be a bottleneck, defined as maximal queue length, using a simple Jackson production network model. Comparison of the analytic model against an empirical simulation-based model shows that the two are in good agreement. A scalar measure of bottleneck shiftiness is proposed and used to investigate several policies for mitigating shiftiness. Simulation experiments show that several commonly observed managerial policies for coping with shifting bottlenecks actually increase shiftiness, but that shiftiness declines when the capacity of nonbottleneck resources is increased.
(CAPACITY; BOTTLENECKS; UTILIZATION; QUEUEING NETWORKS)

## 1. Introduction

We examine the shifting bottleneck phenomenon that often bedevils operating managers. Shifting bottlenecks occur when the location of the bottleneck work center in a production facility changes with time. At a given moment, one work center will be seriously backlogged, causing production delays, whereas only hours or days later another work center will be similarly afflicted. Shifting bottlenecks create control problems for shop floor personnel, since reactive measures to ameliorate a bottleneck (such as expediting, extra labor, or overtime) require management attention and cause disruption at other work centers. Frequently, when one bottleneck has been brought under control, another bottleneck suddenly appears in a totally unexpected location.

We show that shifting bottlenecks are in fact an inevitable result of variability or randomness in the production system. To measure and compare different work centers' contribution to the "shiftiness" of the facility, we first define the bottleneck probability for each work center as the long-run proportion of time a given work center has more jobs in its queue than any other. We obtain the exact form of these bottleneck probabilities for the well-known Jackson network model and demonstrate

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