Capacity Planning under Uncertainty in a Gutenberg Production Model

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Overview

- The paper considers a two stage capacity and production planning model under uncertainty. The optimal second stage production policy falls into three cases: When capacity is slack the firm will produce with the cost minimizing production rate and adjust the production time to meet its output target. When the capacity constraint is binding, the firm will first adjust the production rate and then again produce with a constant production rate but employ overtime to meet the output target.

- The optimal capacity choice of the first stage is determined by the trade off between the sunk costs of slack labor and the expected opportunity costs of adjusting the production rate and employing overtime in the case of a binding capacity constraint.

- The key item determining the firm's labor demand is the overtime premium. The amount of contracted labor strictly increases with the overtime premium and the expected overtime strictly decreases. Since the latter effect dominates the former for small overtime premia, the firm's labor demand is first decreasing and then increasing with the overtime premium.

- A reduction of overtime premia can be Pareto improving because it does not only lead to substantial cost savings but also to an increasing labor demand.

Keywords: Production, Capacity Planning, Uncertainty.

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1 Introduction

The managerial production model of Erich Gutenberg is perhaps one of his most important contributions to the theory of managerial economics. Although the model was already developed in 1951 it still assumes a central place in current German textbooks on production theory. Moreover, empirical studies of German firms in the 'sixties and 'seventies indicate that Gutenberg's production model provides a realistic picture of the production process in the manufacturing industry. Gutenberg felt that the black box model of neoclassical production theory was not well designed to capture the specific nature of the manufacturing process mainly because of the straightforward relation between input and output and the assumption of unlimited substitutability of inputs. To circumvent these limitations he based his model on input functions $a_i(u, z)$ defining production coefficients as a function of the production rate $u$ and the vector $z$ measuring the state of the equipment in use. In the simplest case, the production rate $u$ is measured as the ratio of output $x$ and production time $t$. According to Gutenberg every workplace, or cost center, of the firm can be characterized by the state of its technical equipment, given by $z$. For a given state vector $z$, however, each decentralized unit of the firm can meet its output target in the short run by adopting one of the following three types of adjustment policies.

- Adjustment of production time for given production rate and production equipment in use.
- Adjustment of production rate for given production time and production equipment in use.
- Adjustment of the production equipment in use for given production time and production rate.

Thus, unlike the neoclassical production model, the input required to meet a certain output target is not a choice variable per se, rather it is indirectly