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INVENTORY IN THEORY AND PRACTICE

Edited by ATTILA CHIKÁN

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INVENTORY IN THEORY AND PRACTICE

Proceedings of the Third International Symposium on Inventories, Budapest, August 27—31, 1984

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Edited by Professor R. W. Grubbström, Department of Production Economics, Linköping Institute of Technology, S-581 82 Linköping, Sweden.

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Vol. 2 The Economics and Management of Inventories. Proceedings of the First International Symposium on Inventories, Budapest, September 1—5, 1980. Part A: Inventories in the National Economy. Part B: Inventory Management; Mathematical Models of Inventories (Chikán, Editor)

Vol. 3 New Results in Inventory Research. Proceedings of the Second International Symposium on Inventories, Budapest, August 23—27, 1982 (Chikán, Editor)

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Vol. 6 Inventory in Theory and Practice. Proceedings of the Third International Symposium on Inventories, Budapest, August 27—31, 1984 (Chikán, Editor)

PREFACE

This volume contains 64 papers presented at the Third International Symposium on Inventories (Budapest, August 27-31, 1984) organized jointly by the International Society for Inventory Research and the Hungarian Academy of Sciences.

The Symposium has been organized in order to provide an opportunity for scholars dealing with the various topics related to inventories to exchange ideas thus interfacing rather different aspects. This objective is reflected in the Proceedings.

The papers are published in 3 chapters (Inventories in the National Economy, Inventory Management, and Mathematical Models of Inventories) according to the three sections of ISIR and also of the Symposium. Papers presented at the Symposium have been refereed anonymously. A list of the referees is included.

This volume follows the Proceedings of the previous two Symposia, published by the same publishers under the titles "The Economics and Management of Inventories" and "New Results in Inventory Research".

Attila Chikán

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I. INVENTORIES IN THE NATIONAL ECONOMY

Proc. Third Int. Symp. on Inventories
Budapest, Hungary 1984

A MILLS-TYPE MODEL OF PRODUCTION AND INVENTORY DECISIONS IN THE HUNGARIAN MANUFACTURING SECTOR*

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Our purpose in this paper is twofold. First, some problems of production smoothing approach are discussed and a modified version of Mills' model is developed. Second the production and inventory decision making behavior of Hungarian manufacturing firms is analysed.

For over a quarter century, the Mills model has thoroughly dominated the econometric investigation of production and inventory decisions of firms facing uncertain demand. Indeed this model is often identified as "the" production decision approach to inventories /see Bridge (1971)/. But this dominance has been rendered uneasy by a widespread suspision that the salient facts of modern market economy are inconsistent with the theoretical structure of the model.

Two broad areas of suspision may be identified. The first, concerned with whether inventories are used to buffer output against demand shocks, consists of certain facts that argue against the idea of production smoothing. If firms use inventories to smooth production in the face of fluctuating sales, it is surprising that in many sectors production is more variable than sales. This remarkable fact is profoundly documented in Blinder (1981) and (1983).

The second /by no means unrelated/ area of suspicion centers on the treatment of demand uncertainty and adjustment costs.

This paper developes a Mills type model assuming quadratic costs of changing supply /production plus inventory/ instead of quadratic costs of changing production as Mills did.

The considerations connected with this modification lay the ground for our second purpose: to cope with some problems due to the specific features of production and inventory decisions in planned economies. Here we suggest the simplest modification of the Mills' model that would result in a significant improvement in the description of quantitative feature of the decision making behavior of the socialist firm.

* The authors are greatly indebted to Michael G. Lovell for helpful comments and continuous encouragement. We would like to thank Larry Pollack for estimations of modified model on US data and drawing our attention to the difficulties of estimation of Mills' model.

In Section I. the specification of the modified model is discussed. In Section II. the estimations of the Mills' model and the modified version are compared. Section III. presents econometric analysis of production and inventory decisions of Hungarian manufacturing firms.

The following notation is used: Y denotes production, I stands for the end-of-period inventory of finished goods and X is demand.

I. MILLS' MODEL AND ITS MODIFICATION

Mills (1962) analysed the production, sales, and inventory decisions for a single homogeneous commodity of a monopolistic firm in uncertain situations. He argues that the crucial decision variable is the total supply the firm is to make available during the period, defined by $Q + I_{-1}$ /see Mills (1975) p. 224./. Throughout this paper unit price, p, is held constant. Normally, prices are less sensitive to fluctuations in demand than production.** Sales in each period are the minimum of total demand and total available supply. The demand function is of the form

$$X = X^e + u \qquad /1/$$

where X^e is expected demand and u is a random variable with zero mean uniform distribution in $[-\lambda,\lambda]$. Therefore the distribution of the forecast error term can be represented by a single parameter, λ. As it is derived in Mills (1962) the expected value of total revenue is price times the minimum of demand and supply:

$$E(R)= \int_{-\lambda}^{Y+I_{-1}-X^e} p\,X\,\frac{1}{2\lambda}\,d\,u + \int_{Y+I_{-1}-X^e}^{\lambda} p\,(Y+I_{-1})\,\frac{1}{2\lambda}\,d\,u \qquad /2/$$

The first part of /Eq.2/ applies to excess supply ($X \leq Y+I_{-1}$, i.e. $-\lambda < u < Y+I_{-1} - X^e$), and the second one to excess demand ($X > Y+I_{-1}$, i.e. $\lambda > u > Y+I_{-1} - X^e$).

Four different costs affect the firm's operations in this model. Unit production cost is a constant c, so the cost of production is linear:

$$c\,Y \qquad /3/$$

Carrying cost is a constant r per unit of end-of-period stock and includes deterioration, pilferage, handling, insurance, interest, etc. Most of these are probably proportional to unit production costs, but this need not be shown explicitly

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** Blinder (1982) analysing sticky prices gives some reasons for this fact.

since the latter has been assumed to be constant. The value of inventory on hand depends on the extra cost of producing these goods in the future. Mills takes a situation where marginal production cost is constant and some production is certain to be needed in the next period. /See Mills (1962) p. 109./ Here the value of inventory is the present value of next period's marginal production cost over the cost of storing the inventory for one period. Clearly inventory at the end of this period is not worth less than this amount, since if it were so the firm would make profit by producing and storing more this period, satisfying the greater part of demand of the next period from inventory. On the other hand, the inventory cannot be worth more than this amount, since next period's production serves the same function as the terminal inventory of this period; it is satisfying demand of next period.

So the firm maximizing current expected profits value each unit of inventory at the discounted value of marginal production cost, m, minus storage cost, r. The valuation of inventory in the profit function is of form:

$$\int_{-\lambda}^{Y+I_{-1}-X^e} (m-r)\,(Y+I_{-1}-X^e-u)\,\frac{1}{2\lambda}\,d\,u \qquad /4/$$

The inventory at the end of the period is $Y+I_{-1}-X$ and it is positive if $\lambda < u < Y+I_{-1}-X^e$. Otherwise the firm is unable to satisfy current demand, and shortage costs incure representing estimated future loss of sales, or goodwill. This cost is assumed to be proportional to the excess demand and is given by:

$$\int_{Y+I_{-1}-X^e}^{\lambda} k(X^e+u-Y-I_{-1})\,\frac{1}{2\lambda}\,d\,u \qquad /5/$$

Finally in the Mill's model there is a purely dynamic cost which is proportional to the absolute change in the level of production between any two periods. But in our case it is better to assume a quadratic cost of changing supply:

$$\frac{g}{2}(Y+I_{-1}-Y_{-1}-I_{-2})^2 \qquad /6/$$

The function implies that all such costs are incurred within the planning period in which the change in supply occurs. There may be some grounds in terms or realism for assuming a rising marginal cost of changing supply.

The financing of stocks is strictly regulated in our economy. Any increase in inventories is progressively penalized. As a decrease in stocks has only minor transient benefits to the firm and it may be followed by a sharp increase it also risks rising costs.

The assumption of quadratic inventory costs in addition to quadratic costs of production may have several reasons in market economies too /see Blinder (1982, 1983) /.

The addition of constant to any of these costs does not affect the following discussion. Defining profit, P, as the difference between expected revenue and costs, we have

$$E(P)=\int_{-\lambda}^{Y+I_{-1}-X^e} p\,(X^e+u)\,\frac{1}{2\lambda}\,du+\int_{Y+I_{-1}-X^e}^{\lambda} p(Y+I_{-1})\frac{1}{2}\,du-$$

$$-cY-\frac{g}{2}\left[(Y+I_{-1})-(Y_{-1}+I_{-2})\right]^2+$$

$$+\int_{-\lambda}^{Y+I_{-1}-X^e}(m-r)(Y+I_{-1}-X^e-u)\,\frac{1}{2\lambda}\,du+$$

$$-\int_{Y+I_{-1}-X^e}^{\lambda} k\,(X^e+u-Y-I_{-1})\,\frac{1}{2\lambda}\,du \qquad /7/$$

Differentiating Eq.7 with respect to production, Y, and setting it equal to zero, we obtain an expression for the production decision which maximizes profits. Rearranging it, we get the following expression:

$$Y=\frac{\lambda(p-2c+m+k-r)}{p+k-m+r+2g\lambda}+\frac{p-m+k+r}{p-m+k+r+2g\lambda}X^e+\frac{2g\lambda}{p-m+k+r+2g\lambda}Y_{-1}-I_{-1}+$$

$$+\frac{2g}{p-m+k+r+2g\lambda}I_{-2} \qquad /8/$$

Using the notation:

$$\alpha=\frac{\lambda(p-2c+m+k-r)}{p+k-m+r+2g\lambda} \qquad /9/$$

and

$$\beta=\frac{p-m+k+r}{p-m+k+r+2g\lambda} \qquad /10/$$

eq. /8/ can be written:

$$Y=\alpha+\beta X^e+(1-\beta)\,Y_{-1}-I_{-1}+(1-\beta)\,I_{-2} \qquad /11/$$