# Capital utilization

## A theoretical and empirical analysis

ROGER R. BETANCOURT
CHRISTOPHER K. CLAGUE

# Capital utilization

## A theoretical and empirical analysis

ROGER R. BETANCOURT
CHRISTOPHER K. CLAGUE
*Department of Economics*
*University of Maryland*

CAMBRIDGE UNIVERSITY PRESS

*Cambridge*
*London New York New Rochelle*
*Melbourne Sydney*

Published by the Press Syndicate of the University of Cambridge
The Pitt Building, Trumpington Street, Cambridge CB2 1RP
32 East 57th Street, New York, NY 10022, USA
296 Beaconsfield Parade, Middle Park, Melbourne 3206, Australia



First published 1981

Printed in the United States of America

*Library of Congress Cataloging in Publication Data*

Betancourt, Roger R

Capital utilization.

Includes index.
1. Capital productivity. 2. Capital.
3. Shift systems. I. Clague, Christopher K.,
*joint author.* II. Title.
HD57.5.B47 332'.0415 80-22410
ISBN 0 521 23583 9

# Preface

Our interest in capital utilization began to develop about ten years ago, at a time when the literature was extremely sparse and the topic seemed to be unduly neglected in light of its intellectual and practical significance. After collaborating on a number of articles on the subject, we reached the conclusion during 1975 that the time was ripe to attempt a more comprehensive treatment of the subject. Our aim was to write a book that would systematize the existing body of literature, which by then had grown much larger, while advancing the frontiers of knowledge in several important directions. The reader will be the judge of the success of our efforts.

A project as ambitious as this requires support from a number of sources. On the institutional side, sabbatical leaves to both authors during the initial phase of research for the book were extremely beneficial in two ways. They gave us time to work on the project and opportunities to interact with other researchers working on capital utilization at Boston University (C.K.C.) and at the International Labor Office (R.R.B.). In addition, the General Research Board at the University of Maryland provided summer support for one of the authors (R.R.B.) during 1977. Finally, computer time was provided by the University of Maryland Computer Science Center.

On an individual level, our thanks go to Y. Kim and G. Winston for their very useful comments. These comments led to a substantially revised manuscript that we hope will be accessible to a wide audience of economists. We would also like to thank our colleagues J. Adams, C. Harris, D. Mueller, and M. Olson for a number of suggestions, not all of which were adopted. The typing of the manuscript benefited from the resources made available for this purpose by R. Marris, then chairman of the Department of Economics at Maryland. We also want to express our appreciation for the task of deciphering our handwriting to the following individuals: P. Chiarizia, S. Gordon, S. Pressley, C. Soto, and G. Walton.

To conclude the acknowledgments, our deeply felt thanks go to our friends and especially to our families for their persistent broadening of our horizons beyond the limits of our work.

# Glossary of symbols

| | |
|---|---|
| $\alpha,\alpha^1$ | The shift premium for second-shift work; $\alpha^1$ refers to third-shift work. |
| $\theta$ | The share of capital in combined capital and labor costs under single-shift operation. |
| $\phi(\overline{X})$ | A measure of economies of scale. $\overline{X}$ is the level of output. $\phi(\overline{X}) = \frac{1}{2}$ if there are constant returns to scale and exceeds $\frac{1}{2}$ if there are increasing returns to scale. |
| CR, $CR^1$ | The ratio of system 2 costs to system 1 costs; $CR^1$ is the ratio of system 3 costs to system 1 costs. |
| $\sigma$ | The elasticity of substitution between capital services and labor services. |
| $\beta$ | The degree of homogeneity of the production function. |
| $e^2_{cx}$ | The proportionate increase in average costs generated by cutting in half the level of output under single-shift operation. |

# Introduction

A typical factory can be operated for eight, sixteen, or twenty-four hours per day by making use of one, two, or three shifts of workers. The decisions with respect to the number of shifts are not made, we believe, entirely by accident but depend in large part on economic considerations. Only fairly recently have economists given serious attention to explanations of what these considerations are and how they affect shift-work behavior.

The topic is of considerable intellectual interest in its own right. Moreover, the theory of production is seriously incomplete without a thorough treatment of capital utilization. But the subject should also be of interest to a rather wide audience of economists and other social scientists for at least three reasons. First, the lives of workers engaged in permanent night-work or rotating shift-work are typically adversely affected either by the disruption of biological rhythms or by the reduction in contact with family and community. Second, and on the positive side, more intensive utilization of the capital stock normally increases the output available to the society, both in the present and in the future; the additional output makes possible increased consumption by capitalists or workers or both. Third, a preliminary view of the matter suggests that the distribution of the increased output would be especially favorable to the workers, in the form of higher wages or more jobs.

The practical importance of the study of capital utilization is highlighted by two additional considerations. Not only are dramatic variations in utilization possible, but these wide variations are empirically observed across firms and countries. In addition, the degrees of utilization in various countries seem to have been increasing in recent years. A particularly dramatic example of an increase in shift-work, in this case the result of a conscious governmental decision, occurred in the Soviet Union from 1927 to 1932. A significant fraction of the increase in industrial output and employment during that period has been attributed to the increases in shift-work (Kabaj 1965).

Not surprisingly, economists and policymakers concerned with the

developing countries have become intrigued by the potential employment effects of increased capital utilization. Thus studies of capital utilization in developing countries have been carried out in the last few years under the sponsorship of the World Bank (Schydlowsky 1979; Bautista et al. 1979) and the ILO (Betancourt 1977; Winston 1977b; Kabaj 1978; Phan-Thuy 1979). In addition, the study of capital utilization as an emergency employment scheme has become an ongoing part of the research program of the ILO (1976). On the other hand, in the developed countries interest in the topic has been aroused by the potential output effects of increased capital utilization. For example, the subject lies at the heart of the controversy between Denison (1972) and Jorgenson and Griliches (1972) with respect to the sources of growth in the United States. Needless to say, there are other reasons for the interest in this topic in both developing and developed countries,[1] but we shall not explore them at this point in our argument.

Despite the intrinsic importance of the subject and its practical significance, the current state of knowledge about capital utilization is severely limited in many ways. An important part of the reason for these limitations is the neglect of the subject by economists in the 1950s and 1960s. One important exception to this neglect is the contribution by Marris (1964), but the framing of his contribution in terms of discrete techniques of production no doubt led to its being ignored by many economists. In the 1970s this neglect disappeared. In his 1970 presidential address to the American Economic Association, Georgescu-Roegen discussed capital utilization and noted that it was one of the neglected areas in the economics of production. From the time of that address to the present, the literature on capital utilization has been increasing rapidly, and an excellent survey of developments up to 1974 is available (Winston 1974b). Although some theoretical progress has been made since that date, there are important aspects of the subject that have barely been treated. Moreover, the existing empirical work on the subject, which constitutes a significant portion of the literature published since 1974, is marred by serious econometric problems. In light of the situation just described, this study relates to the literature on capital utilization in two ways. First, it embeds the existing stock of knowledge on the subject in a general and consistent frame-

[1] For instance, in the United States, labor unions are currently showing signs of apprehension or misgivings about increased capital utilization through shift-work (Zalusky 1978); this attitude toward shift-work is prevalent in European labor unions (Maurice 1975, pp. 83–7).

work. Second, it uses the unified treatment of the subject provided by this framework to analyze many aspects of capital utilization that have not previously been investigated.

Our efforts in this book have been concentrated on two major substantive issues: explanation of the decision to utilize the capital stock of a plant, at both the theoretical level and the empirical level, and exploration of the consequences of increasing the level of capital utilization in the industrial sector. These two issues, together with our perception of the role of this study in the literature, have led us to focus on the long-run decision to utilize capital stock. In other words, this analysis will focus on the decision to utilize capital stock at the time of the investment decision, before the plant is built. Most of the theoretical literature is directed at the long-run decision, and with good reason. Because the options available are greater before the putty turns to clay, it is the more interesting decision to analyze, and in many instances the short-run analysis follows directly from imposing special assumptions on the long-run analysis. Moreover, the choices made by the firm at the investment stage condition future choices in a frequently irreversible manner. We shall show, for example, that factories that plan to utilize their capital stock in different ways are also designed and built to operate in different ways (i.e., at different levels of scale and capital intensity). Consequently, the implications that flow from the long-run emphasis are essential ingredients for proper evaluation of policy proposals to increase capital utilization.

This book is directed at two audiences: a specialized one, consisting of those who have done research or are interested in undertaking research in the economics of shift-work; a more general one, consisting of those interested in less-developed countries, economic growth, industrial organization, and labor economics who would like to be introduced to the new and relatively neglected topic of shift-work and capital utilization.[2]

Because the interests of these two audiences will differ, we have made an effort to provide guidelines for choosing where to concentrate one's efforts. The chapters all begin with material accessible to nonspecialists. Those sections that are necessarily technical or specialized are clearly indicated at the appropriate points in the discussion, and the main conclusions of each chapter are described, as far as possible, in ways that the nonspecialist can understand. In addition,

[2] Those interested in applied econometrics should find Chapters 4 through 7 to be worthwhile.

Chapter 0 provides a preliminary and completely nontechnical view of the subject.

In order to facilitate the reading of the subsequent chapters, we shall now describe the overall organization of the study. Chapter 0 contains a preliminary and nontechnical view of the subject. The remainder of the book consists of four parts and a concluding section. In the first of these parts, Shift-Work and the Theory of the Firm, we analyze the long-run decision to work shifts in the context of the theory of the firm. The emphasis is on understanding shift-work behavior and its determinants; nonetheless, important implications derived from the analyses of shift-work for the behavior of the firm are also identified. The focus of Part II, Estimation, is on the process of testing the propositions developed in Part I concerning shift-work behavior, on the shortcomings of previous attempts at testing these propositions, and on the procedures for avoiding these shortcomings. In Part III, Results, we present the findings from testing the theory in Part I with the procedures of Part II and data from France, India, Israel, and Japan; we also engage in international comparisons of the extent and characteristics of shift-work in a wide variety of countries. Part IV, Implications, deals with the effects of changes in capital utilization on employment and wage rates and with the relationships between capital utilization and economic growth. In the concluding section we summarize our findings, evaluate the human costs of shift-work, and suggest an approach to policy.

# Contents



* These starred sections may be omitted without loss of continuity.

# Tables and figures

## Tables

**Figures**

# Propositions

CHAPTER 0

# A preliminary view of capital utilization[1]

In most countries the vast majority of workers go to their jobs during the normal working hours. The majority of business establishments operate only one shift. A great many people, when first confronting these facts, are struck by the apparently low levels of capital utilization that are typically observed. For this reason a good way of approaching our subject is to classify the reasons for capital idleness.

We must first distinguish between intended and unintended idleness. One of the reasons that physical capital lies idle is that events do not always occur in the way that business managers expect. Demand may be less than expected, input supplies may be disrupted, or machinery may break down. These are examples of unintended capital idleness.

The reasons for intended idleness of capital depend on the type of activity involved. For example, some products and most services cannot be stored, and the timing of their production must be arranged to coincide with fluctuation in demand. In addition, many outdoor activities in agriculture, fishing, and construction are strongly affected by the weather and by the amount of daylight; obviously much idleness of capital in these sectors is explained by such factors.

The factors just mentioned do not apply to the great bulk of manufacturing activity, and yet much of the fixed capital in that sector is idle for much of the time. If the degree of capital idleness is regarded as surprisingly high, then it would be well to develop an explanation for the most difficult case, that of the manufacturing sector. The economic factors to which we shall appeal to explain capital idleness in manufacturing will also be applicable to other sectors, but the analyses for other sectors will often be complicated by the special factors mentioned in the preceding paragraph.

In the manufacturing sector, much of the intended capital idleness might be explained by cost-minimizing decisions in the presence of rhythmic variations in input prices, of which the most important is

[1] This chapter may be skimmed or skipped by those familiar with the general topic [e.g., those who have read Winston's survey (1974b)].