1. Introduction

The study of capital utilisation has occupied an increasingly important place in the literature on both the production function and factor demand models, which focus on the relationship between output (itself a per period flow) and the flows of various factor services consumed in the production process. In such models the associated flows are specified for a given period, but the time at which the factor services are consumed in the production process within the period are not considered to be important. To ignore variations in the rate of input flows is to ignore a central technical characteristic of the production process. It may be conceivable that the firm can modify the number of employees required to man a particular machine, at least within certain limits, but it seems unlikely that the vast majority of machines can be left to work unmanned for any substantial period of time. In contrast with the production and employment function literature, the timing of input flows has been a central concern of the capital utilisation literature, but the theories have tended to be simplistic and have not been incorporated into production and employment models.

The research reported in this paper attempts a more realistic explanation of the optimal level of intended capital idleness, linking capital utilisation with the associated patterns of work commonly observed in the real world. In so doing it develops an explanation of the distribution of work patterns and provides a basis on which future research can incorporate this important element of time patterns of work into employment functions. In Section (2) we provide a brief, but critical review of the existing theory relating to optimal capital utilisation and optimal work patterns. Section (3) describes a theoretical framework that attempts to bridge the gap between capital utilisation and the work patterns adopted by firms. This theory depends crucially on the concepts of the least cost labour envelope and the marginal capital savings curve. The data available to test the new theoretical framework are discussed in Section (4). In Section (5) we report on the results of an attempt to establish the least cost labour envelope and the associated average and

1) We would like to thank our colleagues at Loughborough University and at Warwick University who have taken the trouble to comment on earlier drafts of this paper. We would also like to express our gratitude to the European Foundation for the Improvement of Living and Working Conditions, which funded some of our early research in this area. Last, and not least, we wish to thank the organizers for allowing us to present the ideas contained in this paper before a distinguished audience.
marginal cost of labour curves. In Section (6) a similar exercise is reported for the attempt to establish the marginal capital savings curve. These two curves are brought together in Section (7) in order to establish the optimal utilisation/work pattern combination for British manufacturing industry, bearing in mind that the analysis is rather aggregate and the results relate to some form of average or modal position. Finally, Section (8) draws a number of conclusions about the approach adopted in this paper, about the difficulties encountered and about associated policy issues.

Before starting on the main body of the paper, one or two further introductory comments seem to be in order. First, while the research reported below has been going on for some time, a great deal remains to be done. For example, work has only just begun to incorporate shiftworking into factor demand models estimated for the British economy. Second, space does not allow a complete discussion of all of the theoretical niceties, data problems, etc., that we would like to have touched upon. Nevertheless, the interested reader can find further discussion reported elsewhere.²)

2. Review of the Literature

For all that the traditional employment models [e.g. Ball/St. Cyr] say about the matter, labour might work during daylight hours, while the capital stock is run at night. Even the factor demand models that purport to explain capital utilisation [e.g. Nadiri/Rosen] do not develop any links between the timing of various inputs. If it seems reasonable to assume that a machine that is run for, say, 20 hours per day requires a certain cohort of labour to man it at each and every point in time,³) then a new technical link is being introduced that the conventional models cannot handle. Where capital must be manned when it is in operation, then the degree of capital utilisation cannot be independent of the pattern of work adopted by the firm for its employees. The pattern of work chosen has direct implications for the total number of men that the firm will require and the number of hours that each employee will work at any given level of output.

The large and growing literature on capital utilisation appears to fall into two fairly distinct schools. The first has attempted to develop theoretical models of capital utilisation, analysing and explaining⁴) the cessation of productive activities at less than 100 per cent of technical maximum productive capacity caused by rhythmically varying factor prices. While the predictions of such models [Winston/McCoy] give important insights about the causes of intended capital idleness, the assumptions that have to be made to ensure mathematical tractability severely restrict the usefulness of the models in context of the real world. More realistic models will need to take into account somewhat more complicated factor price rhythms and, in addition, the fact that the lengths of shift are

²) A general review of the area (and, in particular, our contribution to the debate) is provided in Bosworth/Dawkins [1981]. A more detailed review of data can be found in Bosworth/Dawkins [1979].

³) This may not, of course, be reasonable in certain processes (particularly where chemical reactions are involved) such as in the production of iron and steel and in certain chemicals industrials.

⁴) We ignore here the work dealing with unintended idleness caused by such events as deficient product demand and input shortages [for a general review, see Winston, 1974, p. 1302; for a discussion of some U.K. examples, see Eels; and for some practical international examples, see UNIDO].