

PB-219 733

CAPITAL UTILIZATION: PHYSIOLOGICAL COSTS
AND PREFERENCES FOR SHIFT WORK

Gordon C. Winston

Williams College
Williamstown, Massachusetts

October 1971

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

BIBLIOGRAPHIC DATA SHEET		1. Report No. PK-309.2-W783	2.	3. Recipient's Accession No. PB-219 733
4. Title and Subtitle "Capital Utilization: Physiological Costs and Preferences for Shift Work"				5. Report Date Oct. 1971
7. Author(s) Gordon C. Winston				8. Performing Organization Rept. No.
7. Performing Organization Name and Address Williams College Center for Development Economics Williamstown, Mass. 01267				10. Project/Task/Work Unit No.
12. Sponsoring Organization Name and Address Department of State Agency for International Development Washington, D.C. 20523				11. Contract/Grant No. csd AID/CSO- 736 & 2475
				13. Type of Report & Period Covered Economic Research Paper-1/65-10/71
15. Supplementary Notes				14.
16. Abstracts Scarce industrial capital is used only a fraction of the time in poor countries though an increase in its utilization would act much like an injection of new capital -- it would increase output, its rate of growth and industrial employment. Extended capital utilization requires night time operation and night operation requires multiple shift working. This raises two questions for social policy: (a) what are peoples' preferences between day and night work and how can they be influenced and (b) is shift work humane? This paper examines evidence on the physiological, social and psychological effects of shift work, <u>per se</u> . These are the major determinants of preferences for day and night work; they influence the social costs of alternative schedules and patterns of shift work; and these are the areas of concern about the potential damage inflicted by shift working.				
17. Key Words and Document Analysis. 17a. Descriptors				
17b. Identifiers/Open-Ended Terms *Capital and labor, Politics *Psychology (Industrial), Politics *Work, Politics				
17c. COSATI Field/Group 309				
18. Availability Statement			19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 34
			20. Security Class (This Page) UNCLASSIFIED	22. Price \$3.75

**CAPITAL UTILIZATION: PHYSIOLOGICAL COSTS
AND PREFERENCES FOR SHIFT WORK**

GORDON C. WINSTON

Reproduced by
**NATIONAL TECHNICAL
INFORMATION SERVICE**
U S Department of Commerce
Springfield VA 22151

RESEARCH MEMORANDUM NO. 42

Center for Development Economics

Williams College

Williamstown, Massachusetts

October 1971

CAPITAL UTILIZATION AND DEVELOPMENT:

Physiological Costs and Preferences for Shift Work*

Scarce industrial capital is used only a fraction of the time in poor countries though an increase in its utilization would act much like an injection of new capital -- it would increase output, its rate of growth and industrial employment [11, 21]. In West Pakistan, industrial capital is used less than 15% of the time while in the United States it is used half again as much [23]. Pakistan does not appear to be unique in this -- it describes a paradox of considerable economic and social importance for most developing countries. The social cost to a poor country of acquiring new capital is high; it is paid for by savings out of meagre current incomes or by borrowing from abroad with its inevitable economic and political obligations.

Why installed capital is so little used, has become increasingly clear [6, 8, 11, 15, 22]. Briefly,

*Paul Clark considerably improved the organization of this paper; Robin Marris was encouraging as usual; Betty Patterson invested hours exploring a literature unfamiliar to both of us; Ghazi Farooq and the Demographic Section of PIDE in Karachi interviewed industrial workers in Urdu; James Halstead argued at every turn and urged me to give it up. None of them is responsible for the fact that I didn't.

One deceptively innocent fact is central; that people prefer to work during the day. To overcome our preference for a "normal" schedule of work and leisure, higher incomes (wages, salaries, profits) must be earned for regular night work. These increase the costs of night time production. But at the same time, extending the period of operation into the night reduces hourly capital costs by spreading the cost of owning the capital stock over more hours of use. Average costs of production therefore may either be raised or lowered by night operation. They will be lowered if the fall in capital costs from extending production into the night is larger than the rise in labor costs. If average costs are therefore lower at night, a high rate of capital utilization will maximize profits for the firm and it will produce any given output with a smaller optimum capital stock. The higher are utilization rates in the aggregate, the higher will be the level and rate of growth of both income and industrial employment. Increased capital utilization is in most respects a substitute for increased saving or borrowing to expand the capital stock. Hence, policies that reduce resistance to night work will increase capital utilization, contributing to income, growth and employment.

Extended capital utilization requires night time operation and night operation requires multiple shift working. This raises two questions for social policy: (a) what are peoples' preferences between day and night work and how can they be influenced and (b) is shift work humane? This paper examines evidence on the physiological, social and psychological effects of shift work, per se. These are the major determinants of preferences for day and night work; they influence the social costs of alternative schedules and patterns of shift work; and these are the areas of concern about the potential damage inflicted by shift working.

I.

There are as yet no data from underdeveloped countries on shift work attitudes, preferences or on its physiological and social effects though the subject has been long studied in advanced countries. Given the importance of the problem to industrial development, we could simply assert that necessity is the mother of analogy. But it seems permissible to be more enthusiastic about using experience from the rich countries since workers and managers in less developed countries are subjected to many of the same kinds of physiological pressures from shift work as are their counterparts in advanced countries; the fact common to both is that they are working and living in conflict with the socially dominant "normal" daily rhythm. Not all aspects of the way people respond to the consequent pressures would be equally transferable between cultures; physiological responses are more likely to be consistent between social and cultural environments than are psychological or social effects of shift work. So evidence of physiological experience will get the greatest attention in what follows.

It could be argued that a study of preference formation -- the factors lying behind a night-labor supply function -- is unnecessary for economic analysis; if preferences for daytime work are strong or weak, they will be reflected in the wage, salary and profit premia people demand for working (or taking responsibility for others' work) at these non-preferred hours.

This is a particularly persuasive argument for an economy where the supply of (at least unskilled) labor is effectively "unlimited" so that the choice for many workers isn't between day and night work, but between night work and no work at all.

Nonetheless, there appear to be two good reasons for development economists to pay some attention to the underlying physiological and social determinants of preferences for and against shift work. They are:

1. that observed wage, salary and profit shift premia tend to be determined by the marginal worker (manager) but the very low present levels of capital utilization in less developed countries imply a massive potential increase in shift work. So existing shift premia or those inferred from advanced country experience simply are not sufficient to estimate the social (or private ex post) costs of a program to increase capital utilization. Shift work will affect workers in ways that are often thought to be negative (and seriously so), potentially offsetting the gains of higher output, employment and growth. And,

2. that the preferences of managers and skilled workers in underdeveloped countries appear particularly important in maintaining low levels of capital utilization so to the extent that these preferences can be understood, better utilization policies can be designed that minimize disutility hence reduce the cost of getting people to work at night.

Both of these deal with the social costs of increased

capital utilization; the first with estimating that cost; the second with the possibility of minimizing it through carefully selected policies.¹

II.

The connection between capital utilization and shift work is almost, but not quite, straightforward. Starting with capital equipment operated only during the day (say for eight hours), utilization can be increased either by increasing the length of time the equipment is worked by a given set of people (with or without payment of overtime wage/salary rates) or by increasing the number of shifts worked. A "shift" typically describes the appearance of a new set of people to work with the equipment. Shift work, in turn, commonly involves people working either fixed or rotating shifts -- working during the same (fixed) part of the day, week in and week out, or constantly changing (rotating) the work period, usually from week to week. These are the major industrial patterns in both advanced and underdeveloped countries [8-S, 12].

The effect on workers of these various ways to increase

1. Government policies in less developed countries now appear seriously to discourage high levels of capital utilization by controlling the relative prices of capital and labor in a perverse direction -- the government makes it relatively costless for entrepreneurs to waste scarce capital [22, 24]. The most urgent policy to encourage capital utilization, therefore, might be simply to stop discouraging it.

capital utilization are different and different analytical issues are raised. The first -- more work by the same people -- involves their allocation of a limited amount of time between work and non-work activities [25].² The second -- fixed shift work, per se, their working and taking leisure in conflict with the normal daytime patterns of society. The third -- rotating shift work -- involves their changing work and leisure time patterns; adhering to no single schedule, whether conforming or conflicting with social norms.

The first of these -- the work/leisure choice -- will not concern us here. The last two pose questions we shall try to answer: (1) what are the effects of working in conflict with dominant social activity patterns; (2) what are the effects of constantly adjusting work schedules; (3) how do these two interact as rotating shift workers move into and out of conformity with socially dominant activity patterns.

In interpreting data on the reactions of shift workers on both shift patterns, it should be remembered that in advanced countries these people are largely self-selected and it is likely that those individuals who would have the greatest difficulty either with conflict or in making repeated adjustments of work/leisure rhythm are simply not found among shift workers -- they long since have taken otherwise less attractive jobs

2. Non-work here will be called "leisure" as this is convenient and conventional despite Linder's chastening analysis of that "leisure" [10].

during the day, reducing the need to adjust [1, 8]. So while we know something about how shift workers do adjust, we know less about how most people would respond to the demands of shift work if they were truly widespread.

A. The Physiological Effects of Shift Work

The physiological effects of shift work have long and frequently been studied but the conclusions by and large are woefully uncertain. (The literature to the mid-60's is well summarized by Mott, et al. [12, Ch. 1] and more recently by Walker for the British Prices and Incomes Board [8-S, Paper 1].) The physical problem suggested by shift work is that the human body incorporates functional rhythms that are usually associated with the time rhythms of the day -- sleeping, eating, elimination, etc. Shift work requires either a one-shot change in those body rhythms (for fixed shift workers) or their repeated adjustment (for rotating shift workers). Whether these adjustments are easy or difficult and what difference difficult adjustment makes to the well-being of the workers will strongly influence their preferences for day work and the social costs of night work.

Time patterns of sleeping, eating and elimination are felt to be among the most "basic" of physiological adaptation to the rhythms of night and day and the most difficult to change [12, p. 234]. Body rhythms themselves appear to have been

acquired in infancy and coincide with rhythmic changes in body temperature, pulse, blood chemistry, etc. over night and day or over the cycle of work activity [2, 8-S, 12]. Despite the fact that these functions are interrelated, the effects of shift work can in part be seen to influence them separately. The level of general health provides an additional if less precise measure of the physiological effects of shift work.

Fixed shift workers work at the same time every day and for them the problem is primarily one of conflict with the dominant social activity patterns and the "usual" relation of work, leisure, light and dark. Though they have ample time to adjust, they live an activity pattern that is at variance with the dominant patterns of their families, neighborhoods and society.³

The most ubiquitous physiological problem in this conflicting activity pattern is sleep. Sleep requires a measure of quiet and that, for a fixed shift worker, suggests either family (and community) cooperation or housing facilities adequate to insulate the worker from them, or both. Whether, in fact, "the central problem of working shifts is getting adequate sleep" [12, p. 235], a shift work labor force that gets inadequate rest

3. They do however complicate this useful characterization somewhat by spending their holidays and often weekends on a "dayshift" pattern in order to conform to activities of their families [8]. There is increasing awareness of the effect of such variability on fixed shift workers [4, 18]. The dominant aspect of fixed shift work, however, remains that of conflict.

can be expected to have lower productivity (assuming that day workers sleep better) and low productivity will be reflected in higher effective shift wage differentials, hence lower capital utilization.

Rotating shift workers are required to adjust their pattern of work/sleep/eat/eliminate every week (or, in rare cases, every month). In that he spends one-third of his work time in complete conformity with society, the rotator's lot is less difficult than that of a fixed shift worker. But since constant adjustment is required, a premium is placed on his ability to change.

The most striking result of studies of rotating shift workers' adjustments is the number of workers who profess to no problems of repeated adjustment in basic physiological functions. Wyatt and Marriott reported that 37% of the workers they studied made immediate adjustment of sleeping times; Mann and Hoffman found that 31% made quick adjustment and even on the infrequent monthly rotation schedule, five percent of the workers adjusted immediately to graveyard shift⁴ sleep patterns (the most difficult adjustment to make).⁵ In the quite careful

4. In the U.S., the three shifts are referred to as "day shift" (usually 8:00 a.m.-4:00 p.m.), "afternoon" or "swing shift" (4:00 p.m.-midnight) and "night" or "graveyard shift" (midnight - 8:00 a.m.). There are a number of variations from these patterns, and names, but these are sufficiently representative for this discussion. For British terminology, see [8-S, Paper A].

5. Interestingly these figures were cited by their authors to show that "only" this many people made immediate adjustment [12, Ch. II].

study of almost a thousand workers by Mott, et al., 80% of the rotating shift workers reported that they adjusted sleep schedules to graveyard shift in less than four days and almost 90% reported the same ease in adjusting to day shift. There is much the same lag in adjustment of elimination. High levels of worker complaints about problems with "time oriented body functions" in the Mott et al. survey were registered by only 6% of fixed shift afternoon workers, 8% of fixed shift night workers and 14% of rotating shift workers. This compares to 3% of the workers on steady days [12]. Even when they first encountered shift work, 58% of the shiftworkers in the Price and Income Survey reported they had had no difficulties in adjusting and another eighteen percent recalled that they had settled in within three months. (Seven percent report they've never made it [8-S, Tables 31 and 32].)

It is interesting that those who have the least problem with adjustment of basic body rhythms are workers who have had a number of years of rotating shift work experience; they show the least negative response in appetite and elimination [12, p. 241]. Whether, again, this is the result of their having learned to adjust or their having selected themselves out as those who adjust most easily [1] is impossible to tell. A good deal of individual variation in ease of adjustment has been found [9].

While the most evident and most important conclusion would seem to be the ease of physiological adjustment and the

number of workers who do not suffer from rotating shifts, it would be a mistake to ignore those who do have real physiological problems in adjusting their basic body functions. Even if some people thrive on the physiological adjustment of rotating shift work, most people don't. Those who suffer from shift work appear to have two sorts of problems: those related to slow adjustment and those related to their conflict, per se, with the dominant social activity time-patterns. Again, sleep is a most sensitive indicator of these problems.

Sleep problems involve both the amount of sleep (too little) and its quality (restlessness while sleeping), and they appear both as a result of slow adjustment to changing shifts and as the result of conflicts with the different activity patterns that surround workers while they try to rest. Rotating shift workers have trouble getting to sleep and trouble staying asleep, and it's especially tough for the first few days after the shift change. In the Mott et al. sample, twenty percent (the obverse of the 80% cited above) were still having sleep problems more than four days after the shift change so on a weekly rotating shift schedule these unfortunate people spent most of their lives being unadjusted [12, p. 238]. For this reason, Walker suggested that weekly rotation may be the most demanding schedule with neither enough time to adjust between rotations nor enough speed of rotation to ride over adjustment without considerable fatigue [8-S, p. 89]. What's more, which shift the rotating worker is on appears to determine the amount

and quality of sleep he gets -- it is worse in both dimensions for the night shift (average amount of sleep is 6.63 hours) and best on days (average 7.77 hours).

The major "quality" problem of sleep for shift workers is "various kinds of noise in their environment" [12, p. 238] suggesting that their conflict with the activity time-patterns of other members of their immediate societies is particularly difficult. Other sleep problems involve "physical upset and over-fatigue" which would seem to imply difficulties of adjustment rather than conflict with an environment that operates on a different schedule of activities. It is significant that rotating shift workers sleep far worse during the day (i.e., when they are working nights) than do regular fixed night shift workers [8, 12]. The rotating shift worker appears less able than is the fixed shift worker to demand that his environment (or he) adjust to reduce the proximity of his conflict with the rhythms of others.⁶

In an underdeveloped country, sleep of shift-workers is likely to take on added importance for two reasons. First, the quality of worker housing is such that the shift worker (actual or potential) is less protected than in an advanced country (or than is management) from noise and interruption of his conflicting family or neighborhood. Second, the lack of spatial

6. A suspiciously small sample studied by Tune, in which shift workers kept a running account of their sleep, casts doubt on even these difficulties. He concluded that "shift workers took as much sleep as others and that this sleep was no more disturbed than usual" [17, p. 184].

separation to soften the conflict between a worker's schedule and that of his family is compounded by extended family responsibilities. The home of a worker is often expected to house as many people as it can without regard to the subtle dimension of the rest and productivity of the host. In both cases, the worker and/or the employer will absorb these costs in disutility and/or low productivity. The problem of sleep, it should be noted, is likely to be less severe, the higher the proportion of workers in a given area (neighborhood, city) working shifts since geographically concentrated shift work reduces conflicts. I will return to this in III below.

The appetite suffers from changing shifts -- it is best on day shift (for 52% of those in Mott's rotator sample) and worst on night shift (for 58%) but a significant proportion of rotating shift workers (25%) claimed that neither shift nor shift adjustment had an effect on their appetites.

Bowel habits appear to be asymmetric -- diarrhea is not associated with shift work but constipation is. What is to be made of this is not clear.⁷ For rotating shift workers, the problems of adjustment generally appear less severe for elimination than they do for sleep. Again the direction of adjustment -- the shift involved -- appears important since 64% of the rotators in the Mott study adjusted to days immediately while

7. Nor is it clear what significance attaches to the Thiis-Evenson finding [12, p. 236] that constipation and colitis are higher among shift workers than day workers in Denmark, but not in Norway.

only 46% adjusted immediately to night shift.

Concerning workers' general health, there is virtually no evidence that shift work affects general health, other than perhaps positively, despite Herculean efforts by students of shift work. Having shown at statistically significant levels that workers most affected by shift work had the lowest incidence of ulcers and the highest level of general health, Mott et al. wrote: "It is difficult to conclude either that days and afternoons are the unhealthiest shifts or that there is no relationship between working shifts and health. To accept these conclusions would seemingly contradict the virtually universal agreement [sic] that there is a relationship between work schedules and such time-oriented body functions as sleeping, eating, and elimination. The data indicate that many shift workers are not getting adequate rest and a proper diet" [12, p. 245].

Since no study of general health has followed a cohort group through the shift work experience, absence of ill effects may rest solely on self-selection (only the healthy survive the rigors of shift work) but they may not. Gastrointestinal disorders and ulcers among shift workers have been studied since 1948 but no clear association has emerged. The thorough study by Mott showed the highest incidence of ulcers on fixed day shift; next to lowest on fixed nights and lowest on rotating. And in their responses making up an Index of General Health (based on the average number of health complaints of various

types), the 974 workers surveyed showed the same refusal to cooperate with scholars' preconceptions. The number of health complaints was largest among day workers, next largest among afternoon, then night workers, and lowest among rotating shift workers [12, p. 243]. From a larger questionnaire study (of 1800 workers), Dirken concluded that "for subjective well-being in both its somatic and psychological aspects shift work can hardly be called a problem" [3, p. 115]. This less dogmatic view seems to have gained increasing acceptance in recent studies. Aanonsen's study of those who had left shift work suggests that "although shift work does not cause illness, it may precipitate nervous or gastro-intestinal disorders in those who are susceptible to them. These men then may leave shift work" [8-S, p. 84]. However, in the Prices and Incomes Survey, only nine percent of those who had left shift work had done so for health reasons [8-S, Table 18] which further suggests that the whole thing isn't very important.

A final finding of the Mott study bears directly (and happily) on capital utilization in underdeveloped countries. Considering fixed shift workers only, the afternoon shift appears to carry no physiological cost in terms of sleep and insignificant costs in terms of appetite or elimination. In fact, workers on afternoon shift sleep more and better than those on day shift; they get to sleep immediately after the shift ends and are under no pressure to get up early in the morning [12, p. 239]. If this happens, too, in underdeveloped

countries, it could be of real importance since the practical question of increased shift work -- given the very low levels of utilization now achieved -- typically involves the inauguration of an afternoon shift and in only rare cases is a night shift in question. In comparing sleep patterns, the silver lining may have a cloud if, as suggested by Walker, rotating workers on afternoon shifts sleep so long because they are making up a deficit of fatigue from poor sleep on night shift [8-S, pp. 82, 89].

Indirect evidence of the physiological (and psychological) effects of shift work may be found in differences in behavior of workers on different shifts -- absenteeism, accidents and levels of productivity have all been examined. But these add little to the conclusion that shift work, at least as performed by those who choose to do it, causes little physiological harm. Absenteeism is generally a bit lower among shift workers [8-S, p. 83]. Accidents are no more frequent at night though working conditions are no more frequent at night though working conditions are sufficiently different (less crowding, less supervision, more casual first-aid) that the comparisons of accident statistics may not mean much. Finally, there is no clear evidence of difference in productivity levels [19]. Experimentally, performance on certain attention-intensive tasks drops with falling body temperature (early hours of the morning) and this is not contradicted in studies of work performance. Among firms interviewed as part of the Prices and Incomes Survey, the

majority felt that productivity was "the same" for night and day shifts, but some felt it was slightly less at night and some, slightly more [8, Table 2]. It seems certain that no sharp and clear difference in worker behavior exists between day and shift workers that might reflect underlying but hidden physiological or psychological effects of shift work.

B. The Social and Psychological Effects of Shift Work

Since they deal largely with workers' expressed statements of their feelings about shift work, the data on the social and psychological effects of shift work are too often vague to the point of being impossible to interpret even for the advanced countries from which they came. Their relevance for people in underdeveloped countries is rarely obvious.

Excepting the recent survey by the Prices and Incomes Board in the UK, in the various cases studied, we (and probably the respondent?) usually have no idea what aspect of shift work is in question, what rewards were paid for shift work or what influence premium night wages had on expressed attitudes. In the one early study where this latter issue was met directly -- Philips -- 36% said they wanted to stay on shift work specifically because of the premium pay. 22% would work shifts even without a wage incentive while, at the other extreme, 42% said they would sacrifice the shift pay premium in order to change to day shift [12]. It would be of real value to know

why these last two groups are unaffected by the shift premium (and if they really mean it) -- what attracts the first group to shift work and why the second group fails to switch to days. But if shift wage premiums were about the same in most reported attitude surveys (they were likely in the range of 15-30%), large differences in stated "liking" of "disliking" of shift work probably are significant in describing differences in intra-marginal preferences. Mott, once again, provides a summary of the literature [12, Ch. 17].

Until the (excellent) study by the British Prices and Incomes Board [8, 8-S7], only the Philips survey cited above had asked whether reactions to shift work were influenced by the premium pay that accompanies it. The evidence from the Prices and Incomes Survey is overwhelmingly that they are. "Good pay" is consistently cited by workers as the most important advantage of shift work [8-S, Table 167], both workers and their wives see "higher earnings" as the most distinguishing characteristic of shift work [Tables 28, 297] and 83 percent of those who said they would look for another job if they were moved from shift work to day work would do so only because they would thereby lose their extra pay (i.e., 17% of them like shift work passionately enough that even if day time pay were as high, they'd look elsewhere for another job working shifts [Table 267]. This interest in pay shows up in the general characteristics of the typical shift worker as a man with a larger family, lower skill level and base salary and greater outstanding

financial obligations [8].

Some findings that are relevant to less developed countries appear consistently enough to be taken seriously.

1. The most important of these is that people are heavily influenced in their attitudes toward shift work by the concentration of shift workers in their communities. In "shift working towns," studies found significantly higher acceptance of shift work among those working shifts than in locations where it was rare. In one isolated single-industry (oil) town in Canada, 88% of the workers said they liked shift work or were at worst indifferent to it (Blakelock, quoted in [12, p. 247]). (The other 12% were generally the higher paid supervisors.) This compares with the typical response -- from German, Dutch, British and US studies -- that half or more shift workers say they dislike shift work [12, pp. 22-23]. The implications of this for underdeveloped countries -- and US economic history -- will be discussed in IV below.

2. Educational level is negatively and significantly related to stated preference for shift work -- with more education people were less happy to work shifts [12, pp. 26-8]. One suspects that this is due largely to social status and expectations which are likely to be even more pronounced in more hierarchical traditional societies typical of less developed countries and especially ones with a colonial background in which social status and shift work rarely went hand in hand. The implications for management preferences in less developed countries are clear

and not encouraging.

3. Among shifts, fixed shift schedules appear much preferred by workers to rotating shifts [12, pp. 58-60]. In one study, however, bizarre war-induced shift patterns (like 16 hours on/32 hours off) were preferred to either of the two orthodox shift patterns [20]. Despite reservations based on the fact that people tend to support whatever status quo they find themselves in [8], this implies that there is a good deal of room for investigation and experimentation with shift patterns with regard both to preferences and productivity.⁸ Alternative shift patterns developed for aerospace crews have been imaginative (4 hours on/4 off, 4/2/4/2, etc.), but their experience is hard to generalize to industrial shift work because in all cases their schedules involved more work time, per se (12 to 16 hours per day in [2], because motivation is unusually high [2] and because commuting distances and inconveniences in a space capsule are uniquely small, allowing frequent changes in status from work to rest. On a more pedestrian level, US automobile workers [16] and a number of British industries [8] are reported interested in ten hour shifts, four days a week, as well as rotation at rates faster than once a week [4].

8. "Denison's Law" that hourly productivity increases with shorter hours implicitly assumes daily regularity of those hours and a reduction of the work-week [3]. It appears not to apply to the sort of 16 hour day described by Walker [20]. In the tests run by Chiles, et al., a 12 hour day (4 hours on/4 off) brought the highest levels of performance for most people, though some did equally well on a 16 hour day (4 on/2 off) [2].

III.

The major implications for underdeveloped countries of these reactions to shift working are.

A. Many People Work Shifts Without Ill Effects

For even the most physiologically demanding work schedule -- that which requires weekly rotation of shifts hence constant adjustment -- roughly a third of the workers involved reported immediate adjustment of rhythmic body functions with changing shifts. The general health of rotating shift workers, taken as a group, appears to be as good as (and maybe better than) that of regular day shift workers. Despite the influence of self-selection, the evidence is that shift work carries negligible physiological costs for many of the workers involved in it in its most demanding form. Utilization policies that increase shift work, therefore, may not carry high social costs to the workers, regardless of which pattern of shift work is used. The following sections do, however, suggest that sensitive choice among shift work patterns can further reduce the costs of shift work.

B. Fixed Shift Patterns Carry Lower Costs to Workers Than Do Rotating Shifts

From the workers' perspective, the fixed shift schedule is superior to the rotating shift pattern except (in UK) when the fixed shift eliminates all evening social life and that's considered important. It appears, therefore, that the subjective costs of adjusting work rhythms are higher than the costs of working in conflict with society, per se. As implied in the discussion of fixed shift workers' superior sleep patterns, conflict with family and society activity patterns seems to be easier to deal with if it is consistent. Fixed shift workers (both afternoon and night) had fewer complaints with "time oriented body functions" than did rotators; their appetites and elimination were better; and shift workers in general expressed preference for fixed over rotating shift patterns. Only for "general health" is there any contradiction to this superiority of fixed over rotating shift schedules.

If workers' subjective costs were the only consideration in devising policies to increase utilization in less developed countries, the implication would be that rotating shift patterns, per se, should be discouraged excepting only rotation around evening work if workers in LDCs share the British worker's strong preference for evening social life.

C. Addition of a Fixed Afternoon Shift Carries Negligible Costs to Workers

In light of the very low levels of utilization in less

developed countries, it is interesting that the addition of a fixed afternoon shift appears to carry virtually no social, physiological or psychological costs for the workers involved. This appearance may be modified

(1) if evening social life is important in an LDC society so a subjective social cost to fixed afternoon shift would have to be reckoned or

(2) if unemployment is widespread so that the reactions of employed workers in either advanced or underdeveloped country are of dubious relevance.

The nature of the data presented here makes this second possibility likely. The workers (advanced country) whose preferences have been reported are, without exception, employed. All the comparisons made -- by them and by the scholars studying them -- are between different work patterns assuming, always, continued employment. But the decision relevant for many workers in poor countries is between night work and no work at all.

No thorough study is yet available, but in a recent interview survey of unemployed industrial workers in Karachi, Pakistan, 34 of the 39 who responded said that they would accept employment on their least preferred shift if it were available and all of them volunteered that their need for income was the reason they'd so quickly violate their preferences. (Of the remaining five, one declined to work nights because of his health; the other four gave no reason for their refusal.)

Comparison of workers' preferences in poor countries

between unemployment and even the most demanding of shift work schedule would, therefore, probably favor shift work by far more than is implied by these data. Rotating shifts might be judged to be very much less attractive than fixed day shift work, but at the same time, much more attractive than continued or sporadic unemployment or underemployment. Responses to this set of alternatives was not included in any of the studies of advanced countries surveyed, so the evidence on shift preferences based on them represents an upper limit to the costs of shift work in a less developed country.

D. Concentration of Shift Work Lowers Its Social Cost

The significant increase in preferences for shift work that comes with geographical concentration of shift workers is of considerable importance for industrial policies in less developed countries. If concentration of shift working industries reduces social costs, a policy of industrial dispersion [14] will carry unexpected costs to society.

There are two reasons for shift work preferences to be strongly influenced by the presence of other shift workers (in addition to reduction of the physiological conflicts mentioned above):

1. If shift work is widespread, larger proportion of the total demand for an area's consumer services is generated at night. With a market during off-day hours, their supply conforms

to work patterns and a major set of inconveniences of night work is eliminated. Pizza, police protection, movies, tea houses, prostitutes, transportation, all become available to the night worker when a sufficient number of them in an area justifies production of these services. "The presence of . . . concentration of industry has influenced the pattern of social and economic activity in the community. Many of the small business establishments in the community have adjusted their hours to the shift patterns found in the plants" [12, p. 57].

2. The second reason is social -- that with a larger proportion of the community working shifts, a larger number of people is available for social contacts by those on shift work schedules that would ordinarily be socially conflicting [6, 12]. The degree of conflict in time rhythms inherent in shift work is effectively reduced. A night worker's schedule conforms to that of a larger part of the population because they come into conformity with his schedule. Illustrative of how far concentration of shift workers in a community can go, in Detroit as many as a third of all workers in manufacturing industries work afternoon or night shift [12, p. 27]. In Holland, 24% of male adult industrial workers work shifts [5].

A case can be made that just such economies of concentration of shift work explain the sharp and discontinuous increase in capital utilization in the United States during World War II and why, once the pressures of wartime production demands were removed, there was ~~the~~ little tendency for utilization

rates either to revert to their pre-war levels or to continue dramatically to increase [7]. Except for a plant that was a very large employer in its area, any individual firm considering an increase in shift work before the War would typically have estimated the costs of night operation on the (reasonable) assumption that the level and quality of complementary night services would not be changed by its decision [11]. When the War caused firms to act in concert, not in isolation, night-work was undertaken widely. Services complementary to night work were increased because they became profitable and worker and manager preferences for day work were reduced by the increased convenience of night work and by the acceptability of working at night for a socially honored (even patriotic) objective. Having made this effective breakthrough by coincidental movement to widespread night work, there was little incentive for firms individually to return to pre-war levels of utilization. By inducing night-complementary services and reducing the social costs of shift work, the war had significantly reduced the costs of night operation to the individual firm, making higher capital utilization profitable where it hadn't been before.

In less developed countries, this recommends policies that either encourage concentration of shift work geographically or that take advantage of an event of wide social impact to encourage a sharp increase in shift work, hence a discontinuous reduction in costs over time.

IV.

This paper has examined evidence, largely from advanced countries, on the physiological, social and psychological costs of shift work to those doing it, both to evaluate those costs and to discover which patterns of shift work minimize them. These are questions of significant importance for less developed countries as they recommend and influence government policies to increase the utilization of scarce industrial capital by increasing shift work. Of special relevance to utilization policies in poor countries are:

1. that for many workers the costs of shift work are negligible,
2. that a fixed shift work schedule is less costly to workers than a rotating shift schedule,
3. that an afternoon shift can be added to a day shift with virtually no cost to workers,
4. that concentration of shift working -- geographically or at a particular time -- sharply reduces its costs.

The empirical evidence reviewed here suggests that the costs of increasing shift work are low and can be reduced further by selection of appropriate patterns of shift work. Even this most likely overestimates the costs of shift work in a poor country -- giving an upper limit -- because the reactions summarized here are with one exception those of people comparing shift work with day work while in a poor country, the more

pertinent comparison will be between shift work and no work at all.

REFERENCES

1. Aanonsen, A., Shift Work and Health, Norwegian Monographs on Medical Science (Oslo; 1964).
2. Chiles, W. Dean, Alluisi, Earl A., and Adams, Oscar S. "Work Schedules and Performance During Confinement," Human Factors, Vol. 10, No. 2, (1968), pp. 143-96.
3. Denison, Edward F., The Sources of Economic Growth in the United States and The Alternative Before Us, Supplementary Paper No. 13 (New York: Committee for Economic Development; 1962).
4. de la Mare, Gwynneth, and Walker, J., "Factors Influencing the Choice of Shift Rotation," Occupational Psychology, Vol. 42, No. 1 (January, 1968), pp. 1-21.
5. Dirken, J.M., "Industrial Shift Work: Decrease in Well-being and Specific Effects," Ergonomics, Vol. 9, No. 12 (1966), pp. 115-24.
6. Eels, F.R., "The Economics of Shift Working," Journal of Industrial Economics (November, 1956).
7. Foss, Murray F., "The Utilization of Capital Equipment Post-war Compared with Pre-war," Survey of Current Business (June, 1963), pp. 8-16.
8. Great Britain, National Board for Prices and Incomes, Hours

of Work, Overtime and Shiftworking, Report No. 161
(London: Her Majesty's Stationery Office; 1970).

8-S. _____, Hours
of Work, Overtime and Shiftworking (Supplement), Report
No. 161 (Supplement) (London: Her Majesty's Stationery
Office; 1970).

9. Kleitman, N., Sleep and Wakefulness (Chicago: University
of Chicago Press; 1963).

10. Linder, Staffan Burenstam, The Harried Leisure Class (New
York and London: Columbia University Press; 1970).

11. Marris, Robin, The Economics of Capital Utilization: A
Report on Multiple-shift Work (Cambridge: Cambridge
University Press; 1964).

12. Mott, Paul E., et al., Shift Work, the Social, Psychological
and Physical Consequences (Ann Arbor: The University
of Michigan Press; 1965).

13. Mann, Floyd C., "Shift Work and the Shorter Workweek," in
Dankers, Clyde E., et al., Hours of Work (New York:
Harper and Row; 1965).

14. Pakistan, Planning Commission, The Fourth Five Year Plan
(1970-75) (Islamabad: Government of Pakistan; 1970).

15. Phillips, Almarin, "Measuring Industrial Capacity in Less

Developed Countries," Discussion Paper No. 110,
Department of Economics, University of Pennsylvania
(January, 1969).

16. "Labor: Thank God It's Thursday?," Time -- The Weekly Newsmagazine (February 1, 1971), p. 47.
17. Tunc, G.X., "A Note on the Sleep of Shift Workers," Ergonomics, Vol. 11, No. 2 (July, 1968), pp. 183-4.
18. Van Loon, J.H., "Diurnal Body Temperature Curves in Shift Workers," Ergonomics, Vol. 6, No. 2 (July, 1963), pp. 267-73.
19. Vroom, Victor H., "Industrial Social Psychology," a chapter prepared for "The Handbook of Social Psychology," Carnegie Institute of Technology, Pittsburg (mimeo and undated).
20. Walker, J., "Shift Changes and Hours of Work," Occupational Psychology, Vol. 35, Nos. 1 and 2 (January and April, 1961), pp. 1-9.
21. Winston, Gordon C., "Capital Utilization in Economic Development," Economic Journal, Vol. 81 (March, 1971), pp. 36-60.
22. _____, "Capital Utilization and Employment: A Neoclassical Model of Optimal Shift Work," Karachi (mimeo, May 1971).

23. _____, "A Comparison of Industrial Capital Utilization in Pakistan and the United States," in Singer, Hans, et al., eds., Readings in Employment and Economic Development (London: Penguin Books; forthcoming).
24. _____, "Overinvoicing, Underutilization and Distorted Industrial Growth," Pakistan Development Review, Vol. X, No. 4 (Winter, 1970), pp. 405-21.
25. _____, "Income and the Allocation of Effort: An International Comparison," Ph.D. dissertation (unpublished), Stanford University, August, 1963.