The Supply of Skilled Labor by Sequence on the Job Training and Vertical Mobility

Larry S. Zudak

Follow this and additional works at: https://ir.lib.uwo.ca/economicsresrpt
Part of the Economics Commons

Citation of this paper:
Research Report 7012

THE SUPPLY OF SKILLED LABOR BY SEQUENCE
ON THE JOB TRAINING AND
VERTICAL MOBILITY

Larry S. Zudak

June, 1970

Not to be quoted without the author's permission
THE SUPPLY OF SKILLED LABOR BY SEQUENCE:
ON THE JOB TRAINING AND VERTICAL MOBILITY*

It has become increasingly evident from observation that the traditional theoretical supply model based on horizontal mobility and variable wages is inapplicable. Large industrial firms employ a variety of skills but workers obtained on the basis of horizontal mobility are usually unskilled to the firm receiving them. Therefore wages are fixed by contract and cannot vary to allocate workers. An alternative supply model is required which can explain the supply of labor in each market of a multi occupational firm. The sequence model developed here with respect to a steel plant will explain the supply of skilled labor on the basis of vertical mobility within the sequence. The derivation will also establish the inapplicability of traditional theory to the steel firm's internal markets and provide alternative definitions of productivity and underemployment. Although the classical model is optimal under theoretical initial conditions, it will be shown that the sequence model is more efficient under steel mill conditions. Finally, other sequence type labor markets will be discussed and some policy conclusions suggested.

The sequence specified by the steelworkers' contract provides the structure necessary to combine on-the-job training\(^1\), protection of investment in human capital and the allocation of labor by vertical mobility. Within this structure, promotion based on continuous service permits skilled labor market equilibrium

---

*I would like to thank my thesis adviser Professor Ed. Ames and Professors Ullman, Brown, Saraydar and Blomqvist and the Manpower Administration for Grant No. 91-16-68-35.

without "hiring" workers outside of the firm, labor quality decrease in critical jobs, variations in wages or long vacancy periods. This equilibrium is possible because skilled labor is a stock within the sequence and most expansions can be supplied from previously under-utilized skills within that stock. Such a system is necessary because certain jobs in a mill such as roller, pourer, first helper, etc. must be performed by qualified workers, just as pilots or surgeons must be qualified, otherwise they may do thousands of dollars worth of damage to the products and waste the time of other workers.

A steel plant is a simplified model of the real world with the initial conditions specified by a single union contract. In the steel industry, skill is the ability to provide a level of work which will allow a machine or process to operate at practical capacity. Since tasks are organized in different ways in different plants, on-the-job training is the only way to acquire many industrial skills. Such training is economical since it concentrates on the skills actually needed. It is automatically modified as technology changes and can be picked up by the worker by being in proximity to the job to be learned. The sequence explains the organization of on-the-job training, how the right worker gets proximity to the job, and provides a basis for organizing the work force, an important factor in determining productivity according to A. Smith, Kapustin and Fenninger. There is an even more significant variable ignored by traditional theory - time.

---


4 Ibid.
Old timers in steel, union or management, will recount that it once took 20 years of on-the-job training to produce a good roller. Even deducting for romanticism, increases in orders would have cobwebs before enough new rollers could be trained to increase output. Since productivity is joint productivity, other workers cannot increase output without an increase in rollers. Since such workers represent substantial capital investment, one method would be to simply carry extra rollers on the payroll. \(^5\) This undoubtedly is done to some extent but to do it for all jobs with relatively long training periods would become prohibitively expensive. Many steel mills already contain twenty thousand workers, carrying extra men would make plants even more difficult to manage. Further, those who worked would envy those who did not, or vice-versa. Thus the sequence must not only explain the organization of production and training, but the expansion of the supply of skilled labor, including highly skilled, without long time lags or carrying large numbers of idle, surplus workers. Finally it must provide the firm and the worker with a system which will permit them to recoup the return on their investment in human capital.

The promotional sequence, or at least sequence like systems, is one of the oldest methods of organizing, training and supplying trained labor. Craft sequences; first year apprentice, second year, through journeyman represent a special type of labor sequence. Craft organizations can be traced back to the guilds of the late middle ages and perhaps even to the artisans of Greece and Rome. In the political sphere the concept has a longer tradition. In England under feudal rules, title and the family estate went to the eldest son.

If he died it went to the next eldest son. The criterion above could be described as depending on which son had the most continuous service in the family, age notability. Jobs higher in the sequence not only pay higher wages but also command more prestige. The worker's social position especially among his peers is related to his position in the sequence just like that of college professors. In developing consumer utility theory biological and psychological needs were appealed to. The hierarchal ordering of society may fulfill similar needs. This natural origin is implied by the systematic way that animals who live in groups develop hierarchal orderings for socio-economic relationships. Similarly, the sequence vests skill and job claims in the worker as property rights. Again, this need for property rights even in the lowest member of the group is found in animals, the "territorial imperative". Thus it is necessary to determine whether the sequence is simply a sociological phenomenon or if it fulfills a technological and economic need.

The Sequence Supplies Labor by Vertical Mobility

In this section a model will be developed which explains the supply of skilled labor. It will be shown that occupations, sequences, are multi-stepped and that the current supply of labor to an occupation is a stock which can be allocated between competing job markets by vertical mobility or promotion. The expectation or fact of promotion with a corresponding increase in wages is the motivation for workers to work as hard as required on their current jobs.

---


7Ibid., chap. 1.
They may also work harder, contribute more to joint productivity, by being promoted to a higher level job.

Wages in a given job class do not rise to attract labor from horizontally competing markets because they do not have the required skills. Instead the supply of labor is increased by inducing a given worker to supply a higher level of skill. Higher wages are paid to workers who promote and increase the supply of labor in higher, more productive, job markets. Therefore the labor markets within a steel mill violate theoretical mobility assumptions in order to satisfy the training requirements of a great many different skilled jobs. Homogeneous unskilled\(^8\) workers are differentiated by training to supply labor with specific skills to particular jobs. The initial conditions for labor markets based on vertical mobility within a sequence are specified in the United Steel Workers' Contract.

**Contract Definition of Sequence**

The labor contract in the steel industry eliminates horizontal mobility by its seniority clause, similar to such clauses in most industrial contracts. Labor economists recognize the existence of seniority but have not used it in stating initial conditions in a rigorous derivation of the supply of labor. Often seniority means length of service. In order to avoid confusion, we shall define it as the union contract does. "Seniority\(^9\) is defined as:

a) Length of continuous service in the relevant unit;
b) Ability to perform the work required;
c) Physical fitness.

---

\(^8\)Only unskilled labor is hired for production jobs. L. S. Zudak, Vol. 1, PB.184069, "A Theoretical Analysis of the Supply and Demand for Labor", Chap. 4.

When (b) and (c) are relatively equal, then length of continuous service as herein defined shall govern promotional opportunity for positions within the bargaining unit, job security during a decrease in forces and preference upon reinstatement after a layoff.

The bargaining unit referred to above is not the same for all unions. In most craft unions seniority is defined in terms of the length of union membership. In many industries seniority is vested in the plant or operating department. In steel plants, the seniority unit is the plant for pensions, vacations and layoffs but it is the **job sequence** for promotions and demotions. Each operating department is divided into job sequences. Job sequences are defined as follows:

"Within each department 'seniority' sequences are set up which are 'intended' to provide, insofar as practical, definite lines for promotion and demotion in accord with logical work relationships, supervisory groupings, geographic locations and such sequences shall be set up in diagram form."

10 See Figure 1 on page 7. "It shall be the specific objective to establish promotional sequences, insofar as possible, in such a manner that each sequence step will provide opportunity for employees to become acquainted with and to prepare themselves for the requirements of the job above. The arrangement of occupations within a promotional sequence are in ascending order of total average earnings on the jobs concerned and any permanent change in such earnings becomes a basis for realignment of jobs within the sequence. If two job earnings are approximately equal the one most closely related to the next higher job is made higher in the sequence."

---

10 P. 80, *op. cit.*, footnote 8.

11 P. 80, *op. cit.*, footnote 8.
PROMOTIONAL SEQUENCE DIAGRAM
BLAST FURNACE DEPARTMENT (SHEET 1 OF 3)

NOTES:
1. REVIEW DATE NOVEMBER, 1961
2. PERMANENT VACANCIES FILLED IN ACCORDANCE WITH PROVISIONS OF ARTICLE VII, SEC. 6, SUB-PAR (A) (2) OF THE COLLECTIVE BARGAINING AGREEMENT OF JAN. 1960
3. A SERIES OF VERTICAL LINES CONNECTING GROUPED BOXES AT APPROXIMATELY THE SAME RATE LEVEL INDICATES ADVANCEMENT ABOVE THE BOXES SO-CONNECTED IS DEPENDENT UPON PROMOTION THROUGH ONLY ONE OF THEM.
The fact that jobs above the entry level are not offered\textsuperscript{12} to new workers has two effects:

1. Jobs above the lowest level (job class 2) are inaccessible to people not currently working in the plant. This eliminates from job markets within any steel firm competition from outside workers. It divides the labor market into external markets and internal markets which are effectively non-competitive.

2. It will be shown empirically in the mobility section that the U.S.W. contract effectively eliminates horizontal mobility between theoretically competing labor markets within the firm. Above the entry level, the horizontal mobility of labor is very low. For higher job classes it approaches zero.

Figure 1\textsuperscript{13} is a promotional chart for the sequences within a department. Promotional sequences are arrays of related jobs diagrammed in ascending order of pay, effort and responsibility; each job is training for the next. A man enters the department at the bottom. While in the department's labor pool, a worker can choose to enter any of the sequences shown in Figure 1, each of which represents a fairly long term commitment. Promotion, and the opportunity to prepare oneself for promotion by working on the next higher job when the regular men are sick or on vacation, is based on continuous service in the sequence. The worker cannot transfer from his sequence to another without sacrificing all the seniority and advancement time accumulated. In order to change sequences he must return to the unskilled labor pool and wait for entry into a new sequence.

\textsuperscript{12}See Chap. 3, \textit{op. cit.}, footnote 8.

\textsuperscript{13}This information is mill data supplied anonymously by steel firms. Data supplied in this manner will henceforth be referred to as Mill Data.
Before proceeding with an example of a sequence and a discussion of its theoretical implications, three points should be clarified. First, not all sequences are simply a straight ladder, some lead to another plateau where a second set of choices must be made. But this does not change the essential nature of the process. It converts the next step up at some level into a probabilistic step.

Each job in the sequence falls into one of thirty-five job classes, each with a different wage. Jobs requiring the same skill, effort, responsibility, etc., are in the same job class. Jobs in the same job class pay the same base wage. It is obvious that just as the top dentist does not earn wages as high as the top medical doctor, not all steel mill sequences will contain equally highly paid top jobs. One sequence may terminate at job class 10, others at job class 16, others at 32, etc. Not all sequences have the same number of job classes nor the same number of jobs between two job classes. The worker may expect to spend different amounts of time in progressing from one job level to another in different sequences. These differences become part of the basis for a worker to choose one sequence out of the heterogeneous selection offered to him.

Finally, the contract makes it possible to go from job \(j\) to \(j + 2\), but it states that a worker must come down the way he went up. In a contraction the worker who skipped \(j + 1\) may find himself back on job \(j\) while a friend who did not skip step \(j + 1\) is still working on \(j + 1\). Thus sophisticated workers do not normally skip steps. It will be established, in the tables that follow, that they are not normally given an opportunity to skip a step. The worker with the most seniority on job \(j\) almost always accepts promotion to \(j + 1\).
Example of Sequence Allocation of Labor by Vertical Mobility

An example will establish the ability of the sequence in Figure 1 to expand and contract the supply of labor, and the maximum expansion possible with fixed wages and no hiring in outside markets. It should also help to clarify the relationship of continuous service, training cost, to labor quality. Assume that the level of output is at capacity. The demand for labor is specified by union contract at four workers in each job market in the sequence. 14

The dates of entry into the sequence can be designated by letters with "a" being the man with the "oldest" date, "b" the man with the next oldest date, etc. The sequence will initially assign men to jobs on the basis of continuous service as follows:

Table 1

Millwright Sequence

(1) Keeper: a, b, c, d
(2) Cinder Snapper: e, f, g, h
(3) 1st Helper: i, j, k, l
(4) 2nd Helper: m, n, o, p
(5) 3rd Helper: q, r, s, t

We assume that four crews of five men each are involved in output. If there is a 25% decrease in output, demand, the number of crews needed in this sequence decreases from four crews to three. The contract states that in a reduction only continuous service counts. The youngest men are laid off first. d displaces e for millwright leader, e displaces f, f displaces g, and g displaces h. This process is colloquially called "bumping". 15 In real terms d displaced g and

---

14 Specified by the standard crew agreement, see page 257, Zudak, Vol. II, PB.18070, op. cit., p. 4.

h, g and h effectively displaced j, k and l; j, k and l effectively displaced m, n, o and m, n, o in turn displace p, q, r, s, t. These five men are dropped to the labor pool. In the pool a similar process will decide who remains employed in the plant. The process by which these men are actually discharged is based on departmental seniority. In order to simplify the analysis, it will be assumed that the workers dropped to the labor pool were all laid off.

The new job assignments are:

Table 2

Contracted Millwright Sequence

(1) Keeper: a, b, c
(2) Snapper: d, e, f
(3) 1st Helper: g, h, i
(4) 2nd Helper: j, k, l
(5) 3rd Helper: m, n, o
(6) Laid off (Labor Pool): p, q, r, s, t

Groups 1 through 5 inclusive represent workers who remain in the sequence and at work. Some workers in all of these groups, except group 1, have experienced a demotion and a decrease in pay. The supply of labor in each job market (1) through (5) above has been contracted by vertical mobility. In the traditional model a demand shift in one labor market changes wages which causes a shift in supply in horizontally competing markets. In this model a demand shift changes the continuous service, training, required to hold each job causing a supply shift in one or more vertically competing markets. The marginal worker, promoted or demoted, receives a different wage even though the wage rate for each job remains fixed.

In economic theory the wage allocates labor between competing markets. Could this not be interpreted as vertical mobility rather than horizontal? For
this interpretation to be valid, equilibrium would require that wage differential between market \( j \) and \( j + 1 \) be such that all workers who were qualified and wished to work in \( j + 1 \) at current wages were permitted to do so. But in the real model above worker \( d \) who may be at least as qualified as a, b, or c, is not permitted to do the top job. Therefore it is difficult to argue that wages or quality are the variables although this system does use training cost, service, as intensively as possible. This should not surprise economists since the wage differential between full professors and associates is not permitted to vary to the point that no qualified associates wish to promote at current wages. Nor are associates with tenure dismissed to provide room for better assistants, etc.

The only economic justification for the maximization of quality is that it minimizes the factor cost of labor. In theoretical models where generalized labor is thought to produce output at maximal efficiency the quality of the individual is meaningful. In the industrial economy output is produced not by individual workers but by crews. Figure 1 is a part of one such crew. Expansions in output are accompanied by the promotion of workers with less training time and the quality of the individual worker may on the average be declining.\(^{16}\) But this decline is not reflected in labor productivity which steel mill executives contend rises with the level of output. This paradox occurs because the efficiency of the crew increases as output expands by the more effective utilization of fixed labor components.\(^{17}\) The firm is interested in minimizing

\(^{16}\) As suggested by Reder, p. 313, op. cit., p. 2.

\(^{17}\) P. 55, R. Conrad Cooper, "Steel and Inflation", U.S. Steel Corporation, New York, 1957.

the cost of the crew not its individual components. Promoting workers who may be individually less skilled permits an increase in the efficiency of the crew and a lower marginal cost.

An increase in the supply of labor in each sequence job market can be achieved by simply reversing the contraction process. Promotion makes possible a greater increase in the supply of skilled labor, 33 1/3%. In this initial expansion based on currently laid-off and underemployed workers, problems of allocating workers, their qualifications, search and training are all solved by promoting workers to jobs which they have previously held. The problem of determining the workers' ability is solved. The firm is able to expand its supply to any level at which it has worked in the recent past. Even if its production fell to the two-crew level increases in output to four crews would remain feasible for some time because workers would retain their ability to promote by working in higher level jobs when the regular workers were sick or on vacation. It is only after prolonged depression such as the 'thirties that expansions, such as the War required, may create skill problems.

In order to be able to expand the supply by promotion it is necessary that underemployed workers and unemployed workers remain in the sequence rather than seeking their maximum marginal product elsewhere. The problem of the unemployed worker who is completely cut off from his income will be discussed first. Both analytically and by contract those workers who were laid off, (group 6), are still part of the sequence. If a vacancy occurs, workers will be recalled to the sequence in reverse of the order in which they were laid off. The senior laid-off worker has opportunities to work in other sequences or even other departments of the same plant. The real question is how the worker who is actually laid off survives. Geographically steel mills tend to be located close to industries to which they tied cyclically, coal,
automobiles and railroads, or isolated in mill towns. This means no massive alternative source of employment is available to unemployed steel workers. Further other companies will not hire steel workers on lay off because they know they will return to the mills when recalled.

The union contracts in steel were written after the institution of the state unemployment compensation programs of the "New Deal". These provided the worker with alternative sources of survival. By the 1950's, the state programs had become so inadequate that some supplementary program had to be devised. This need was met by the supplementary unemployment program in the steel and automobile union contracts. A worker must have two years of seniority to qualify for the benefits. The cutoff in this range is not arbitrary. It represents the amount of continuous service which coincides with enough training invested in the worker to justify the firm's payments of benefits to retain him. It should correspond to the maintenance and depreciation costs incurred by the firm on idle capital.

The Mobility Characteristics of the Sequence

In the last section a model of supply was derived which assumed that the supply of labor in a sequence is a stock which is allocated between sequence jobs by continuous service, a flow. Assuming that trained labor is a stock contradicts the traditional assumption that the worker is horizontally mobile between competing labor markets. In this section it will be established empirically\(^{19}\) that labor is not horizontally mobile between competing job markets even if they are in the same plant. If this lack of mobility is based on the workers

\(^{19}\) All data in Figures 3 through 6, Mill Data, provided anonymously by steel firms.
desire to protect his investment in job training, then mobility would be expected to decrease at higher job levels as the tables below show. In order to demonstrate that the sequence supply model of vertical mobility be based on continuous service is valid, it will be shown empirically that management offers workers promotion on the basis of continuous service and that workers thus selected accept that promotion.

**Horizontal Mobility**

There are three possible types of horizontal mobility out of a sequence:

1. Quit;
2. Discharged;
3. Changed to another job with the same company.

Traditional theory only considers (1) and (2) explicitly. The possibility of multi-job firms is generally ignored. Considering the first type of mobility, the management of a steel firm was asked by the author in November, 1967, "what percentage of the men in the nine representative sequences in three different departments quit last year?" Their answers are tabulated below by sequence.

<table>
<thead>
<tr>
<th>Sequence Quits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No.3 Open Hearth</strong></td>
</tr>
<tr>
<td>Floor Sequence</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td><strong>Mobile Equipment Sequence</strong></td>
</tr>
<tr>
<td>1 employee - 7%</td>
</tr>
<tr>
<td><strong>Electrical Sequence</strong></td>
</tr>
<tr>
<td>2 employees - 15%</td>
</tr>
</tbody>
</table>

20 Executives seemed to feel answers in this period representative of general situation.
The second type of worker mobility is involuntary mobility, firing. Management was asked at the same time, "what per cent of the men in each representative sequence was fired"? In the group of sequences above only one man was fired.

The third type of mobility is mobility between internal labor markets, sequences. In order to show that mobility is primarily a function of the job class held, the amount invested in training, mobility is tabulated by skill level\(^2\) for each sequence in the table below. Management was asked: "how many of the employees in each of the sequences were formerly in other sequences and what was the job class of the occupation they held in the former sequence before leaving?"

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Unskilled</th>
<th>Semi-Skilled</th>
<th>Skilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor</td>
<td>6/90</td>
<td>2/90</td>
<td>0</td>
</tr>
<tr>
<td>Mobile Equipment</td>
<td>3/17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electrical</td>
<td>00</td>
<td>2/13</td>
<td>0</td>
</tr>
<tr>
<td>Temper Mill</td>
<td>0</td>
<td>1/15</td>
<td>0</td>
</tr>
<tr>
<td>Inspection</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electrical</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\(^2\)Unskilled is less than job class 6, semi-skilled to 16, skilled over 16.

\(^2\)Floor sequence 1st, 2nd and 3rd helper is one of the most desirable sequences in the mill; it is also one of the most critical. Therefore skill is tested and continuous service is not sufficient.
Vertical Mobility

In order for vertical mobility to explain the supply of labor, the company must be willing to offer higher level jobs to workers on lower level jobs and the workers must be willing to accept these. They must be willing to be promoted. A further reason for continuous service as a criterion is motivation and administration. In the absence of increasing wages it has been suggested that hourly or bonus workers would supply additional work because it was necessary to retain their jobs and qualify for promotion. The contract says jobs will be on the basis of ability, really successful training, and continuous service. If the promotion is to motivate labor, it is necessary that the worker be assured that his efforts on lower level jobs will not go unrewarded. If promotion was based on ability defined as intelligence quotient, education or "ability" many workers would find themselves permanently trapped in the lower rungs. In that case, promotion could not be considered a motivator of labor for many workers. Also, union leaders and the company find it hard to agree on the criterion whereas continuous time is a historical fact. Therefore the real criterion for promotion is continuous service except for a few key skilled production and maintenance jobs which require tests. The following table based on a question to the management of a large steel mill, "What percentage of workers currently in the sequence, members during this year, have been refused promotion who would have been promoted if continuous service were the only criterion?"

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Unskilled</th>
<th>Semi-skilled</th>
<th>Skilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor</td>
<td>0 %</td>
<td>33 %</td>
<td>50 %</td>
</tr>
<tr>
<td>Mobile Equipment</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electrical</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Temper Mill</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Inspection</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electrical</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

23 See footnote 18.
The table shows that the firm supplies jobs almost solely on the basis of continuous service. The hypothesis that the firm fills jobs by promotion on the basis of continuous service, seems to be well established. It is still necessary to show that the firm can rely on promotion to supply trained labor.

If the worker with the most seniority refuses promotion, it will be offered to the next senior worker. If he accepts, the above table would record that the job was filled on the basis of continuous service. But the dependability of vertical mobility as a means of supply would be less than if the workman with the most seniority has accepted. His refusal would reduce the stock of qualified labor available. It would also impair the effectiveness of on the job training which is based on providing the most training, vacation replacement, etc., to the oldest man on the job below. If the acceptance of promotion by the oldest worker has a low probability, then employers are not necessarily training the right worker. Therefore the management of a large steel mill was asked "How many workers currently in the sequence, during the current year, have refused promotion?"

Table 6
Promotion Refusals

<table>
<thead>
<tr>
<th>Sequence</th>
<th>0</th>
<th>0</th>
<th>13/90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Mobile Equipment</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electrical</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Temper Mill</td>
<td>0</td>
<td>0</td>
<td>1/15</td>
</tr>
<tr>
<td>Inspection</td>
<td>0</td>
<td>0</td>
<td>1/18</td>
</tr>
<tr>
<td>Electrical</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

The table shows that in 6 sequences in 3 different departments, all but an insignificant number accepted promotion to a higher job. Thus jobs are filled by promotion according to the contract, promotions are offered first to the senior man in the job below and workers seldom refuse promotion.
The sequence and unemployment compensation enable the employer to retain workers in whom he has a substantial investment without carrying them as excess labor in their current jobs. Part or all of this cost is passed on to the worker who pays it by working at less than his full potential, including unemployment. Workers with the most seniority and on the job training are the best protected, insuring both the company and workers' return on investment. The sequence provides a means for organizing cooperative work and on the job training on the basis of job relationships. Most important, it retains a stock of trained workers to be allocated by continuous service, making possible a predictable expansion or contraction in the supply of skilled labor without long lags or carrying workers at a loss.

SEQUENCE SUPPLY MODEL

In this section a simplified sequence supply model will be specified which will summarize the preceding discussion and provide a basis for determining the generality of the sequence model and its policy implications.

Since any model based on underemployment is bound to raise questions of economic efficiency or rationality, it is necessary to establish the economic functions required of the sequence and the effect of these requirements on the applicability of traditional maximization models. The marginal model cannot be applied directly to a steel mill because it only explains the optimal allocation of labor between competing production units but not between skilled jobs within such units except by implicitly assuming that isoquants represent efficient points for homogeneous labor units. Nevertheless, the inapplicability of the marginal model can be established implicitly by showing that the sequence is less costly than a linear optimizing which
recognizes differing aptitudes and skills but continues to ignore four characteristics of modern industry:

1. the cost of internally training workers for a diversity of jobs,
2. cost minimization which must be carried out dynamically because of the business cycle etc.,
3. inability to test for some highly skilled jobs,
4. worker motivation and job choice.

Gale\textsuperscript{27} offers such a linear model to explain job assignment in a factory where there are "$n" different jobs to fill, $J_1 \ldots J_n$, and "$n" different applicants, $I_1 \ldots I_n$. Each applicant is given an aptitude test to determine his fitness for each job. Let $a_{ij}$ be a non-negative number giving the rating of $I_i$ for the job $J_j$. The problem is to determine what fraction of time $I_i$ should work at job $J_j$ assuming only one person can work at a job at a time in order to maximize the sum of the ratings. It is possible to formulate a linear program and show that the solution is always feasible. This mathematical problem assumes that an efficiency expert can design a test to test the efficiency of each individual on each job and then successfully compare the scopes of these workers and assign them jobs. Unfortunately, even if the efficiency experts succeed, they also have a cost.

A labor relations specialist with considerable experience pointed out that a steel mill department may have 250 jobs and 1,000 workers, and a large mill contains 4,000 jobs and 20,000 workers. If each job's test required only one hour per worker, the total number of hours spent testing would be 250,000 hours for a department, and 80,000,000 hours for

a plant. These workers are employed by the plant and would have to be paid to submit to four thousand hours of tests at a base wage of about $3.00 per hour. It would cost 240 million dollars just to test the workers in a plant for the jobs in that plant. The efficiency experts render the analytic model inapplicable by specifying four thousand different jobs. Where does this optimizing process stop? What is it worth to a large company like United States Steel with five or ten such plants? Even if it is assumed that U.S. Steel only maximizes in each plant, the cost would exceed 2.4 billion dollars, approximately one billion dollars more than the company's total employment cost in 1956. This cost does not include the computer hours required to process the tests and prepare the administer them. It also ignores the cost of training the workers thus selected for the jobs they will occupy and the loss output suffered while the labor force takes tests and trains.

The cost of linear maximization is even greater when dynamic factors, business cycle, technology or new applicants, require that one or more workers be released. Consider a new applicant. He must be tested for four thousand jobs. If he is better than at least one existing worker, the difference between them would have to be compared with the cost of training him. If the original worker was then released his tests would have to be compared with those 19,999 other workers before laying him off. If he is better than one of the other workers that worker is let go setting off new waves of reallocation and retraining. This practice either statically or dynamically might maximize labor efficiency but it would hardly minimize cost and its effects on output as a function of worker morale and organization would be incalculable.

Even if testing were feasible, it is impossible to expect even a worker with a great deal of aptitude to perform many jobs without experience. Workers would have to be chosen for a training program without being able to
determine their aptitude. For really critical jobs, the only type of training program possible is on the job training with lower level jobs being used as training steps for higher level jobs. Thus under any system the firm and workers are required to invest substantial amounts in human capital without any provision in a theoretical optimizing model for ensuring their ability to collect their return on that investment.

A complete discussion of how the worker chooses a sequence is beyond the scope of this study, but a brief discussion will clarify how the sequence reduces the problem of allocating new workers. By grouping jobs into sequences, the problem of choosing among four thousand jobs is reduced to several hundred sequences. Training time and cost is eliminated since it takes place automatically and so does dynamic reallocation by vertical mobility with fixed wages and excluding outside workers. Since promotion is based on experience and on the job training, the company can reduce its testing problem to one test given to all workers who are then free to choose any sequence without further testing except for a few critical jobs and crafts. The worker's choice problem is made more manageable by restricting his choice to a single department, twenty or thirty sequences for the first two years. The worker must view his selection of a sequence entry job both as a job and as an investment. The worker receives a wage for the job he performs, but he is investing part of his lifetime into learning to be a carpenter, etc., instead of something else. The worker can depend on a return on his investment in skill since the company must pay enough to retain him in order to collect its return on investment. In selecting an entry job, the worker is choosing not one job but a whole sequence of jobs. Unlike the hypothetical worker in traditional theory, the steelworker can and should consider the discounted value of the sum of the wages for each job in each sequence under consideration and choose the one with maximum expected
lifetime earnings. This automatically includes the worker's return on investment but also includes any other differential payment for risk, heat, etc. Thus, the worker does not choose an entry level job in a sequence solely or even primarily by comparing the wages of the entry level jobs and thus steel wages and bonuses are fixed for each job class during the contract.

If the marginal model had been defined for specific skills as some textbooks assume, then it would be inapplicable for the same reasons as the linear optimizing model as an explanation of the allocation of trained labor between competing jobs, firms or industries. In the typical two labor market model, a change in demand in market A raises the price shifting the marginal revenue product and raising wages until enough workers from market B move horizontally to bring wages back to equilibrium. Marginal revenue product and wages are higher in both markets because labor is mobile and substitutable. Output has increased in A and decreased in B since full employment is assumed. Changing hundreds of wages and bonuses every time demand changed would have the same costs as in the linear model and would be ineffective because most workers cannot do jobs in other sequences or often even their own job in another plant. Further, it is unnecessary because the full employment assumption is violated. The supply of labor in steel can increase without decreasing output or supply in another market by promoting underemployed skilled workers within and hiring unskilled workers from among the unemployed eliminating the need for short run wage variations and horizontal mobility except among unskilled workers in the sequence model outlined below:

28 For a complete discussion, see Ch. 4, Zudak, op.cit., p. 5. Also, see Becker, op.cit., p. 3.

1. Labor is organized in sequences of related jobs within which workers are trained on the job to form a stock with specialized skills.

2. In the period when the contract and stock of training are fixed, the stock of labor available to increase the supply in any job is limited to previously trained workers working in lower job classes and vice versa during a contraction.

3. The supply of labor to any sequence job market is a function of sequential service, work experience. An increase in product demand will create an excess demand for labor in some sequence job markets. This excess demand will be filled by decreasing the continuous service necessary to hold each job. This increase permits labor to move vertically to supply the increased demand in each market and to replace workers promoted to higher jobs. Thus a shift in demand in any job market is met by shifting the supply in lower level job markets in expansion and higher level in contraction.

4. The shift in the supply of labor in each sequence is transmitted down until it results in a shortage of supply in the unskilled labor pool. This is the only market which can by contract and training requirements hire labor from outside the firm, i.e., unskilled labor from unemployment or horizontally competing labor markets.

5. In equilibrium, underemployment may remain even though supply equals demand in each job at the contract wage and promoted workers are contributing more to production and earning higher wages for it.

The sequence provides a micro definition of Keynesian unemployment and an explanation for many empirical observations not predicted by the marginal model. Keynesian underemployment is defined in the sequence as those workers with sequence job claims working below their maximum skill level including
unemployment, with or without SUB, making the truely unemployed those without jobs or job claims. Given business cycles, taste changes etc., workers do not attain their highest productivity except by accident like macro full employment. The sequence thus establishes a relationship between the level output, business cycle, underemployment and each worker's level of productivity and wage. Vertical mobility based on training time within the sequences replaces horizontal mobility based on wages in supplying and allocat- ing labor providing an economic theory of "upgrading" a phenomenon whose practical importance has long been recognized by Manpower, unions and even civil rights groups. This promotional model would predict, for example, that older workers, more experienced, should occupy more skilled jobs at higher pay and be less likely to be unemployed than younger workers.\textsuperscript{30} Once un- employed, the older worker, like economically underprivileged, is more likely to remain unemployed because training him does not represent an attractive human investment. Before discussing the implications of these predictions, it will be usefull to establish the generality of sequence.

\textbf{GENERALIZATION OF THE SEQUENCE}

If the analysis of the sequence as a system for organizing, training and allocation is correct then sequences should be observable wherever these functions are needed. Further if there are sequences in many other industries, then the traditional theoretical model is inapplicable for the same reasons as in the steel mill. Finally, such a generalization would suggest a general applicability of the sequence analysis developed here to other industries and occupations.

The generalization can be discussed in terms of other specialized skill industries like steel and those using generalized skills such as the building trades. The sequence system is used in other industries covered by the steel contract, over one million workers. It is also used by the United Mine Workers, 600,000 members, Sulfate and Paper mill, 170,000 members. Figure 2-2 is a sequence of a large public utility which was identical to that in steel until about four years ago when it was modified somewhat.

A simplified sequence in which all training occurs in the early years is used by the building trades, about three million workers, and other apprenticeship occupations like the meatcutters and machinists. There are about 250,000 apprentices of all types in programs requiring from two to six years training. In such crafts however stepwise demotion is not normal. The worker either works at his achieved level or demotes to unemployment. Before laying off journeymen, all apprentices, day card holders and perhaps journeymen from other locals will be laid off and journeymen will instead perform their jobs. Instead of varying sequence service in response to demand changes, crafts vary test criterion and the training time required to attain journeyman status. These changes in requirements are then transmitted downward until the number of new apprentices accepted each year is changed. A decrease in demand would be expected to produce an increase in training time, continuous serve, and test requirements. The excess in each apprenticeship step would be eliminated by attrition and by reducing the acceptance of new apprentices.

The military services and non professional civil service grades representing both general and specific training are also organized into sequences. The army military occupational specialties MOS, shown in Figure 2-3 for the transportation corps have the same terms as the steel sequence but react to a contraction by increasing time or test results like the crafts. Once a soldier
Figure 2-1

Public Utility Sequence

Army Sequence
RAILWAY OPERATIONS AND RAILWAY MAINTENANCE

<table>
<thead>
<tr>
<th>GRADE</th>
<th>LOCOMOTIVE OPERATOR</th>
<th>TRAINMAN</th>
<th>RAILWAY MOVEMENTS SPECIALIST</th>
<th>STEAM OR DIESEL LOCOMOTIVE REPAIRMAN</th>
<th>RAILWAY CAR REPAIRMAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-9</td>
<td></td>
<td></td>
<td>SGT MAJOR</td>
<td>1ST SGT</td>
<td>1ST SGT</td>
</tr>
<tr>
<td>8-8</td>
<td></td>
<td></td>
<td>1ST SGT</td>
<td>CH RWAY HCO</td>
<td>1ST SGT</td>
</tr>
<tr>
<td>8-7</td>
<td>SR ROAD FMN: ENGR</td>
<td></td>
<td>SR ASST TO:MASTER</td>
<td>SR DISPATCHER</td>
<td>SHOP FMN</td>
</tr>
<tr>
<td>8-6</td>
<td>ROAD FMN: ENGR</td>
<td></td>
<td>ASST TO:MASTER</td>
<td>DISPATCHER</td>
<td>SM OR D&amp;E LOCO NSP</td>
</tr>
<tr>
<td>8-5</td>
<td>FMN</td>
<td></td>
<td>ENGR</td>
<td>CMNDUCTION</td>
<td>SM OR D&amp;E DRAH</td>
</tr>
<tr>
<td>8-4</td>
<td>FREEMAN</td>
<td></td>
<td>SR BRAKEMAN</td>
<td>TOWERMAN</td>
<td>SM OR D&amp;E LOCO DRAH</td>
</tr>
<tr>
<td>8-3</td>
<td></td>
<td></td>
<td>BRAKEMAN</td>
<td>ASST TOWERMAN</td>
<td>CAR CARPENTER</td>
</tr>
<tr>
<td>8-2</td>
<td></td>
<td></td>
<td>RAILWAY MAINTENANCE HELPER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-1</td>
<td></td>
<td></td>
<td>TRAINER</td>
<td>(Labor Pool 0)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2-3

has begun in a sequence he cannot transfer if his rank exceeds the maximum, usually private first class, of the desired sequence. In order to transfer he must either leave the Army forfeiting rank and pay and re-enlist in that sequence or secure a waiver to transfer which will not be granted except when there is a shortage. Recruiting sergeants state that waivers are not freely given to protect the Army’s investment in training the worker for his present sequence. Thus it seems that the sequence concept and conclusions apply to many industries using both general and specific labor especially key occupations, those characterized by long training periods.
SEQUENCE POLICY IMPLICATIONS

Having suggested the generality of the sequence supply model, it is now possible to discuss the policy implications of its predictions about structural and socio-economic underemployment.

One function of the sequence is to protect the worker and firm's investment in human capital from the loss due to cyclic downturns. It may also help to trap him in an obsolete occupation or declining industry. The worker's skill makes him vulnerable to structural unemployment because it will not transfer to other industries. Also, the more skilled a worker, the less willing he is to give up his investment to seek other employment. Firms which pay well for trainable workers will not hire him because he is too old to justify a new investment in training. The only jobs available are low skilled, essentially nonindustrial employment. The coal miner who was unlucky finds himself barely able to survive while a steel worker who started at the same time is earning fifteen thousand dollars a year. The system of vesting the worker with job rights, continuous service, unemployment insurance and supplementary unemployment benefits may help to trap the worker by conditioning him to accept periods of underemployment and by making it possible for the worker to wait for the industry to recover. For example, Chicago area steel firms attempted to hire workers in Appalachia during a recent labor shortage and failed. Those refusing to accept new jobs who gave a reason said that other workers who accepted automobile jobs in another state found themselves laid off and unable to collect unemployment compensation in their home state or the new one. This suggests that at a minimum unemployment compensation should be national and should include relocation expenses and continuing financial support to the newly relocated worker. It also seems that in an economy which benefits so substantially from the technology made possible by specialization that an unlucky occupational choice should be treated as an insurable occupational hazard just as death, accident or short term cyclic lay off. Tax rebates from income taxes paid in good years should also be available to these workers as they are to actors and football players.
The sequence also explains the firm's refusal to employ socio-economically disadvantaged workers. The firm does not set irrationally high standards for the hiring of laborers as some economists and even educators\(^\text{32}\) have asserted. Rather, the firm sets realistic standards for hiring unskilled workers who must become rollers, millwrights and electricians. The firm attempts to maximize quality at the current wage.\(^\text{33}\) Workers with qualifications below a certain level, high school for a steel firm, will not ordinarily be hired. These workers are industrial unemployables who are underemployed as dishwashers or carwashers waiting for a chance to "get into the mill". When labor markets are tight, a lower step is added to the sequence and workers with previously unacceptable qualifications are hired. Institutions such as the job corps, night school and HIT\(^\text{34}\) etc. can be viewed as attempts to extend the sequence downward and institutionalize a transitional step. This step attempts to invest the social overhead capital in the deprived worker that has been automatically given to other workers.

The problem is that once the worker is hired the firm cannot force him to continue his education to qualify for entry and promotion into the sequence even though voluntary programs are offered by the Manpower Administration.\(^\text{35}\) One way of inducing the company to hire more deprived workers might be a contract clause stating that workers hired without a diploma should be kept on probation longer than the customary six weeks so the company could fire them if they fail to attain the minimum education level required by their sequence, often high school, within a reasonable period.

\(^\text{32}\) (Canadian) "Education Minister criticized employers who require high school and university degrees when they are not needed for the job," Canadian Press, Toronto, April 18, 1969.

\(^\text{33}\) P. 313, Reder, op. cit., p. 1.


Conclusions:

1. Linear optimizing is inapplicable and marginal analysis based on horizontal mobility and variable wages is ineffective as explanation of internal labor supply in the contract period. Horizontal mobility was shown to be negligible and wages fixed.

2. The supply of skilled labor in a firm is trained and retained by sequences. The supply can be varied by changing continuous service, training, to increase or decrease the supply of skilled labor in a given job market by vertical mobility. The worker increases his supply of labor by performing a more skilled job at a higher wage.

3. The whole crew is required to produce output, joint productivity. Since productivity depends on how intensively the firm uses its labor force and then skills, a worker's contribution to joint productivity is a function of the maximum skill level at which his continuous service and the level of operations permit him to work.

4. The sequence model provides a micro definition and measurement of Keynesian underemployment. The existence of the sequence, specialized skilled labor, implies the existence of structural unemployment and at least partially explains the underemployment of educationally deprived workers.

5. The existence of specialized skill changes the employment bargain for both the worker and management from that of a current wage paid for current output to one involving future skilled labor inputs to produce future outputs. This is explicitly recognized in the union contract which makes firing workers with over 30 shifts worked, about six weeks nearly impossible. To make this bargain the firm must be a corporation deathless. The firm attempts to maximize the quality of unskilled workers hired at the contract wage in order to insure a sufficiency of trainable workers since they may be training for more demanding jobs in the future. The worker making a lifetime investment in skill must not only consider the discounted value of the return on investment in each sequence, but the total expected lifetime earnings of the occupation and its vulnerability to the business cycle and technical change. The derivation and application of this choice function as a means of allocating unskilled labor between lifetime occupations when current wages are fixed provides a topic for future analysis.