Skills Obsolescence: Individual, Organizational, and Market Definitions and Implications

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Abstract

This paper extends our earlier discussion of skills obsolescence in examining economic determinants of skills obsolescence. Theory and research are reviewed and discussed from individual, organizational, and market perspectives. The role of management performance in the etiology of skills obsolescence is described. Examples of organizational strategies to avoid or reduce obsolescence are detailed.

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Skills obsolescence is often examined during periods of apparent economic and political adversity. Within the United States's recent past, such events as the Soviet Union's pioneering space ventures, the advanced engineering of passenger vehicles for energy conservation by Europeans and the Japanese, and a failure to compete with foreign producers (particularly the Japanese) in developing competitive new products have been partially attributed to obsolete, inadequate, or inappropriate skills in the labor force.

While skills obsolescence is a critical issue for organizations and individuals and is a subject frequently alluded to in the popular press, we have noted elsewhere that there has been little theory development or empirical testing of proposed causes and linkages in the skills obsolescence process (Fossum, Arvey, Paradise, and Robbins, in press).

In the present paper, we extend the discussion begun in Fossum et al (in press) by first introducing and defining the job level variables involved in skills obsolescence; second, by summarizing theory and research on individual decisions associated with skill acquisition; third, by examining organizational uses of skills in the production function; fourth, by examining changes in the product market leading to skills obsolescence; and fifth, by suggesting ways in which individuals and organizations attempt to cope with skills obsolescence.

Skills Obsolescence Concepts and Definitions

Skills obsolescence is ultimately an individual level phenomenon. It results from an incongruence between the embodied employment related assets of the individual and the demands of the job. In this section, we will define

the terms knowledges, skills, and abilities; introduce the concept of labor as a derived demand; examine the role of changes in derived demand in creating skills obsolescence; and offer a definition of skills obsolescence.

Knowledges, Skills, and Abilities: Definitions

From a psychological standpoint, knowledges refer to content information acquired through formal education, on-the-job experience, or other media which are managed and recalled through cognitive processes and used to direct purposeful behaviors important for individual goal accomplishment. Knowledges are foundations for performance, but require behaviors directed by knowledge to convert them into performance. Skills are the psychomotor processes used to translate such knowledges into the behaviors necessary to accomplish individual goals. Abilities are defined as the present capabilities or achievement levels of an individual (Dunnette, 1976). They may be thought of as the breadth and levels of knowledges and skills possessed by the individual.

Abilities should be distinguished from aptitudes. Aptitudes are capacities to learn the knowledges, skills, and abilities (KSAs) needed to achieve individual goals. KSA acquisition rates vary between and within individuals and depend on the aptitudes and/or motives of the individual. Unlike KSAs, aptitudes are not susceptible to change in the short run, but may improve or decrease with age, use, and other factors.

In employment, bundles of KSAs embodied in individuals are hired to accomplish organizational goals. KSAs are combined with raw materials and capital in the proportions which represent their most efficient uses in generating a profit. Thus, from an economic perspective we define KSAs to be human attributes that can behaviorally operate on raw materials and physical capital to produce outputs having economic value.

Derived Demand and Tasks, Duties, and Responsibilities

Organizations sell or provide goods and services to the market. Consumers make choices with regard to the types and levels of goods and services they purchase given their income levels. Thus, the demand for labor by the hiring organization is derived from the level of demand in the market at the prices consumers are willing to pay. In turn, the types of products and services that are currently demanded in the market determine ultimately the KSAs that employers will be hiring.

KSAs are embodied in the individual and may not be exactly configured as the employer would desire. Given the other inputs to the organization's production function (raw materials and capital) jobs are configured with particular tasks, duties, and responsibilities (TDRs). The TDRs require certain KSAs to produce the products and services. Thus, we may define job characteristics in terms of either TDRs or KSA requirements (Dunnette, Hough, & Rosse, 1979). From an economic perspective, TDRs represent the demand side of the employment relationship and KSAs the supply side.

Changes in the Demand for KSAs

TDR changes may result from both exogenous and endogenous changes to the organization. An exogenous change affecting TDRs and their required KSAs would occur if a new production technology were introduced by a capital goods supplier. If it were adopted by an employer to improve profitability, the reduced proportion of certain TDRs that are included in the firm's production function would lead to an incongruency with KSAs presently possessed by employees. Changes in the internal organization or work procedures used by a firm are examples of endogenous changes creating TDR-KSA mismatches.

Within the organization, jobs or tasks within jobs might be divided into two different categories. The first relates to the creation of goods and services that are ultimately sold in the marketplace. The second relates to the support activities necessary for the operation of the organization in producing the goods and services. The first type consists primarily of general human capital (GHC) KSA requirements while the second includes many specific human capital (SHC) KSAs which are required to coordinate operations among specific individuals and units given the current roles and structures in the organization.[1] Obviously, jobs vary in the degree to which they contain each of these types of TDRs.

Changes in demand for products and services may display (among other types) both cyclical and secular (long run) trends. The derived demand for KSAs may undergo similar types of changes due to either specific product demand or changes in the relative prices and attributes of factors of production.

From the individual's perspective, the occurrence of a secular change in the demand for KSAs is a function of the period of time necessary for acquiring KSAs (with equivalent earning power) for the jobholders. For example, if the employee is in an organization or an industry that is experiencing a three-year decline in demand for certain goods and services and the retraining period and cost necessary for acquiring new skills and obtaining new employment is less than the period of reduced demand and the lower wages or unemployment benefits during the downturn, then the change can be said to be secular for the individual. Cyclical changes are those in which the expected earnings from a new set of KSAs minus the expected cost of training and job search are less than the level of unemployment benefits during the downturn period and the future expected earnings after the unemployment spell is over. When the demand

for KSAs by the organization is viewed from this perspective, then a cyclical downturn should be accompanied by some organizational action designed to raise (at least) the perception of high cost or low benefits from acquiring different KSAs by the redundant employees (cf. Foster & Wan, 1984).

The KSA requirements of jobs in the U.S. economy have changed relatively rapidly during the recent past. Evidence (Rumberger, 1981) suggests that the KSA level requirements of many jobs have increased while the skill distribution within jobs has narrowed. If the speed of change is accelerating, and if aptitude levels are constant, higher occupational skill requirements must be coupled with narrowed skill variety to maintain equal levels of learning and performance. Even KSAs with relatively long training requirements (e.g., engineering specialties) have changed quite rapidly with some estimates of 50 percent obsolescence occurring in less than ten years (Zelikoff, 1969) for occupations where the nature and capabilities of products and services change rapidly. Consider, for example, the changes in computer memory technology over the past twenty years. In the middle 1960s fast memory was almost completely handled by iron ferrite core memory modules. By the 1970s, solid state storage began to take over. Along the way, bubble memories were also considered, but rejected. Each of these requires substantially different technical training for their development. An engineer schooled in magnetic memory media theory and applications would have to relearn a substantial repertoire to be competitive in the labor market with one schooled in solid state technology.

It is these types of changes in demand that lead to our definition of skill obsolescence.

Skills Obsolescence: A Definition

We have previously stated that:

> [Skills] obsolescence occurs when the person requirements of a job which are demanded by its tasks, duties, and responsibilities become incongruent with the stock of knowledge, skills, and abilities currently possessed by the individual; given that these knowledges, skills, and abilities were previously congruent with job demands (Fossum et al, in press).

One implication of this definition is that a more rapid change must take place in the KSAs required by the TDRs than in "possessed" KSAs for skills obsolescence to occur.

Individual Considerations

Individuals are assumed to choose and develop KSAs for occupations which offer the most positive outcomes for them given their investments (Becker, 1975; Smith, 1776). Human capital theorists suggest that individuals make investments in training (which are represented by out-of-pocket costs and foregone earnings) to improve their income streams. This notion can be extended to include not only income but other employment related outcomes which are important to individuals (cf. Schwab, 1982).

The initial choice of what KSAs to acquire and develop probably begins to form early. Children observe role models and apply their aptitudes to solving problems in their environments. Vocational interests are formed and information about potential types of employers is assimilated. These childhood developments equip individuals to make the specific choices that will help to direct their evolving careers (Crites, 1969; Holland, 1976; Schein, 1978; Super, Starishevsky, Matlin, & Jordaan, 1967). These early experiences and tests shape the inputs to individual choice models in human capital and expectancy theories that we will examine later.

Aptitude Effects on KSA Acquisition

While we noted earlier that aptitudes are relatively permanent compared to KSAs, levels of specific aptitudes vary between individuals and over time within the same individual. Readers of the sports pages are greeted frequently with news of the retirement of a sports personality. In most cases the retirement follows a period of declining performance. It's unlikely that the decline is due to an erosion in knowledge, but rather to the level of skills and abilities that can be exerted as physical aptitudes deteriorate with age. While peak physical capacities deteriorate somewhat with age, there are few data suggesting that mental capacities (demonstrated by tested skill and ability levels) suffer the same decline (Baltes & Schaie, 1974; Birren, Cunningham, & Yamamoto, 1983).

As product demand and production technology change, the skills and abilities possessed by jobholders occasionally become obsolete. If the skill and ability changes are within the same aptitude areas, the jobholder may have little difficulty adapting to them if sufficient time is available. In every case where a KSA change occurs, the first requirement for adaptation is learning the new knowledge that will govern the psychomotor operations required to develop and exhibit the skill at a sufficient ability level. As change increases in speed and/or complexity, higher levels of mental aptitude are necessary for adaptation at the present width of TDRs assigned to jobs. This is not to suggest that knowledge acquisition alone can accommodate change. Operationalization of the adaptation by the individual is demonstrated by the skills s/he displays through employment behavior.

Expectancy Theory Explanations of KSA Acquisition

Given equal aptitudes, the choice of what KSAs to acquire is a function of the perceived outcomes associated with successful completion of the acquisition program. From a motivational perspective, the choice is clearly explainable using expectancy theory (Campbell & Pritchard, 1976; Lawler, 1971; Vroom, 1964). Individuals will invest in development if they believe their efforts will allow them to acquire KSAs, that these KSAs will be in demand by employers, and that employment will lead to higher levels of positive outcomes (given the costs of attaining the KSAs) than other sets of KSAs. Where other outcomes are equal, wage differentials would serve as the outcome which would govern the choices that individuals make regarding which KSAs to develop.

We suggested earlier that expectancy theory has a variety of implications for the study of KSA development among individuals (Fossum et al, in press). Implications from expectancy theory include the following:

1. If the outcomes that were preferred by the individual at the time the KSAs were acquired are not the same outcomes that are important to the individual now, it would be unlikely that the individual will see much utility in maintaining or acquiring new KSAs which only lead to attainment of the devalued outcomes.

2. If the individual believes that efforts to attain KSAs will not yield them as efficiently as before, then less effort will go into their development. This may result from possible declines in the aptitudes for acquiring KSAs and/or increasing costs of time and/or foregone income necessary for their acquisition.

3. Individuals may (correctly) perceive that their aptitudes for

acquiring new or higher levels of KSAs are below capacities required for higher levels of development.

4. If the individual does not expect to receive higher returns for time and income foregone in acquiring KSAs, s/he will not make the investment.

5. If the expected benefits stream from the present job exceeds the expected stream from those of a different set of KSAs, new KSAs are not likely to be acquired.

Human Capital Theory Explanations of KSA Acquisition

KSAs can also be considered within a human capital perspective. Consistent with theories of human capital (cf. Becker, 1975, Schultz, 1961, Thurow, 1970), we may divide KSAs into general and firm-specific human capital (GHC and SHC, respectively). The currency or obsolescence of GHC is dependent on the current derived demand (TDRs) for labor (KSAs) reflected in the overall market's demand for goods and services which are produced competitively (either as definable goods or as potentially substitutable goods) and their use in the production function. The currency or obsolescence of SHC is dependent on how the individual organization defines and allocates TDRs necessary for its internal operation. It should be noted that TDRs assigned to the innovation and development of new products not currently available in the marketplace require KSAs which are at least partially SHC in nature. When new products and services appear in the marketplace, to the degree that they are not protected by patents, those TDRs shift into the GHC domain. As will note later, this distinction has major implications for an organization's training and development strategies.

While there are many consistencies between expectancy and human capital theories, they differ somewhat in their perspectives. Human capital theory has

tended to examine the returns to relatively formal training or experience over relatively long time periods while expectancy theory has concentrated on the perceived consequences of choices individuals might make. The empirical research done by students of human capital has tended to focus on the returns over individual careers (cf. Becker, 1975), and hence has examined carefully the interrelationship between aging and KSA development investments. From an individual perspective, human capital theory suggests that (other things equal) the willingness to invest in new or enhanced KSAs declines with age because the total return will be smaller. This is reasonable since a finite life leads to shorter asset recapture periods with age. But, a number of conditions might mitigate this implication. These conditions can be summarized in a set of "if" statements. If the KSAs to be developed will yield all of their possible returns during the anticipated remaining work life of the individual, if the individual believes that KSA acquisition abilities or aptitude levels are equal to or exceed those of younger employees, and if the income foregone from development is not greater than for younger employees, then KSA acquisition decisions should be unaffected by the individual's age.

The Supply of KSAs

KSAs (given our economic definition) are acquired to enhance the economic wellbeing of the person in which they reside. Individuals would be expected to acquire those KSAs they believe are within their capabilities, for which they forego the least income, and which they expect will have the greatest long run return. McDowell (1982) notes, for example, that there are differences in the sex compositions of academic disciplines which can be partially explained by the durability of knowledge contained in each. He suggests that women who expect to spend some time out of the labor force in childrearing investments

would rationally choose to develop KSAs in academic disciplines least prone to erosion over time. His finding that the physical sciences are proportionally occupied at a much higher rate by males than the humanities provides some support for this proposition. Higher incomes are necessary to induce individuals to acquire, at their cost, relatively nondurable skills.

From the individual's perspective, the application of embodied KSAs in an employment context leads to economic returns. If the total utility from a type of employment requiring a certain set of KSAs is greater than other sets that individuals might acquire, over time these high return KSAs will be acquired leading to a larger supply in the labor market. Unless there is restricted entry to an occupation through licensing, labor union contracts, and the like, the returns from a specific set of KSAs will decline over time as the supply increases even though they may still be congruent with TDR requirements. This can be expected because individuals would seek to develop GHC (given their aptitudes) for which rates of return are higher than normal. Over time, the influx of persons into occupations demanding these KSAs would reach an equilibrium level and the abnormal returns would no longer be achieved. The MBA market over the past twenty years demonstrates this phenomenon.

Acquisition of GHC KSAs might be expected, in most instances, to lag demand in the labor market since a disequilibrium would be required to create wage differentials sufficient for individuals to choose these new development areas as compared to those which were previously popular (and in demand) (Freeman, 1979). Within the organization, the development of SHC KSAs might also be expected to lag their demand with one notable exception. In research activities, organizations may have a broad product development goal, but may not be able to predict exactly how this goal will be realized. To the extent

that an organization innovates a new product that is eventually successful in the marketplace, it is the sole economic entity in which the particular KSAs associated with that product are found. The development of the KSAs are coincident to and necessary for the development of the new product and are SHC to the organization because they are unknown in the external market. As long as the organization maintains secrecy about their development and is able to reach the market with its new products cloaked in secrecy until they are introduced, its supply of product specific KSAs confer an advantage on it (cf. Glaser, 1985). At that point, however, the thought processes, physical activities, and achievement levels (KSAs) become GHC if the product is successful.

It is likely that KSAs not only erode at different rates across occupations, but there are also likely to be differences in the proportions of KSAs that become obsolete during a given time period. For example, in electrical engineering, KSAs are continually eroding as new knowledge is developed regarding the electrical properties of materials in different environments. The electrical engineer who does not keep up with these changes can find that a large proportion of previously job-related knowledge has become worthless over a relatively short period of time. However, these changes occurred continuously and no major portion of developed KSAs were rendered obsolete instantaneously. On the other hand, a production employee using a particular set of equipment may use the same KSAs without much modification for several years, then suddenly find that a majority of them are valueless as a new assembly system is introduced. The rate of change over time is greater for the engineer than the assembly worker, but the "chunkiness" of the change is greater for the production employee. It is likely that only the engineer can

be expected to continually develop KSAs as part of his/her labor supply behavior since the use of new KSAs by the assembly worker depend on the introduction of new technology by the firm.

Individual Changes and Obsolescence

Age-obsolescence relationships found to date suggest that significant innovations and discoveries are often associated with relative youth (cf. Lehman, 1963). However, this may be as much a function of job design as age where organizations encumber more innovative, and perhaps generally higher aptitude, employees with coordination TDRs as their tenure increases. Several studies suggest that obsolescence appears to accelerate with age, but they also point out that obsolescence appears to be lowest during middle portions of professional careers (Dalton & Thompson, 1971; Doering, Rhodes, & Schuster, 1983; Shearer & Steger, 1975). It may be specious, however, to suggest that relatively young employees have obsolete KSAs. It is more probable that their KSAs are not fully developed at the time that they are initially employed and that practice in a job's TDRs is necessary for KSAs to achieve full job applicability.

Education-obsolescence relationships have been found generally to be negative (Dalton & Thompson, 1971; Shearer & Steger, 1975). There are a number of possible explanations for this finding, but two which are particularly appealing are that: (a) education is associated with the creation of knowledge and skill acquisition abilities--thus enabling the individual to modify and update as necessary as long as the skill acquisition abilities are still applicable; and (b) higher levels of education are pursued by those who have the highest levels of aptitudes for skill acquisition, particularly where education is seen as a primary vehicle for obtaining lifelong valued outcomes.

Interest patterns of individuals also appear to be related to obsolescence with those have broader interest patterns (Dunnette & Kirchner, 1958; Kaufman, 1972; Pelz & Andrews, 1966) appearing to be more innovative and higher performing. Updating may be more automatic among individuals with broader interests since they may see implications for their jobs from a wider potential set of sources (Arvey, 1973). Using an ecological analogy, persons with wider interests are more likely at any point in time to find their interests congruent with at least some portion of the job environment.

Individual aptitude patterns and levels are also probably associated with obsolescence. If TDRs increase in difficulty within a given job set, the individual's aptitudes must be at levels sufficient to enable KSA growth at the same or greater rates. If TDRs formed by the derived demand for goods and services change in character, then previously appropriate aptitude patterns may cease to be valuable for job performance. For example, if job designs in drafting occupations require more mathematical aptitude and less spatial aptitude as drafting activity moves from the board to the computer terminal, then previously competent draftspersons may not be convertible to computer-assisted-design technicians.

Organizational Considerations

Embodied KSAs are hired by organizations to fulfill TDRs required by their production functions. These production functions and the TDRs they require are derived from the demand for their products and services. All organizations, however, do not demand similar bundles of KSAs (either across or within themselves). The differences in demand ultimately stem from the pursuit of different segments of the product and service market.

Organizations are assumed to develop strategies which are consistent with their perceptions of what goals would be best to pursue to maximize some organizational outcome (e.g., profit) (cf. Porter, 1980). Given these types of goals, one could assume that organizations will seek to concentrate on marketing products and services that can either be provided more efficiently than others while fetching the same price, or in creating new products and services that they believe will create new consumer demand and offer (at least in the short run) some monopoly profits for the innovator.

Either of these two strategies will require the development or configuration of KSAs which are not generally available in the external market. Thus, the production function of more successful firms (either through improved efficiency or product innovation) will not be the same as others which do not achieve higher than normal returns.

In the next section, we will examine the effects of changes in the product and service market on the outcomes of employers. We will argue that, for employers, skills obsolescence is realized when competitors' profits (measured on some relative bases) exceed theirs when the raw material and capital components of the production function do not significantly differ. We will further argue that the onset of skills obsolescence is only related to relative deficits in SHC and the way it is created and managed by the organization since GHC would be in perfectly elastic supply to the firm in the labor market.

Market Influences on Skills Obsolescence

In this section we will consider the effects of the introduction of a new product or service on wages and employment in firms and/or industries affected by this introduction. We will also examine the effect of elasticities of the

demand for and supply of KSAs on individual, organizational, and market outcomes.

Product Substitution Effects on Derived Demand

Elementary microeconomic theory (cf. Ferguson, 1969) indicates that a change in the price of an existing good or the introduction of a new or improved good leads to a change in the relative prices of other goods and/or real income for the consumer. Consider, for example, the introduction of solid state memories in computers. This resulted in a decline in the costs of storing information that ultimately led to the possibility of the microcomputer market. Increased efficiency in this memory medium, as well as advances in magnetic media, enabled many small to medium businesses to use electronic data processing for the first time, rather than manual filing and recall of information. Figure 1 shows the effect of the introduction (and rapid price decline) of solid state and more efficient magnetic media on the use of computers and manual filing systems. Assume that the Y axis represents the quantity of manual filing systems (F) demanded and the X axis the quantity of electronic data storage and retrieval systems (C) demanded given the relative price relationship of the two. The relative amount of each demanded, at any given point in time, depends not only on consumers' tastes but also on the relative prices of the products. Assume that FC represents a budget line which stands at the frontier of the combinations of F and C that can be purchased with a given sum of money. At a given level of real income (say I), a consumer may be indifferent to a variety of combinations of F and C. Indifference curve I shows, for example, that there is some minimum of either manual filing systems or electronic systems that the consumer desires. The price of either would have to fall greatly for less of the other to be purchased at the tails

of indifference curve I. The amounts of F and C purchased are determined by the point of tangency of indifference curve I with budget line FC. In this case, y_1 of F and x_1 of C would be purchased.

Now assume that solid state memories and magnetic media improvements led to substantially lower costs for electronic as opposed to hard copy storage. The reduction in price for computing equipment would shift the budget line from FC to FC'. Other things equal, the real incomes of consumers of storage media would increase since they could purchase more for the same nominal amount. Indifference curve II might represent their preferences for filing and computing equipment at this new higher income level. The point of tangency of indifference curve II with FC' is at R with y_3 units of manual systems purchased and x_3 units of electronic systems.

Insert Figure 1 about here

With the quantities of manual and electronic systems demanded changing to y_3 and x_3, respectively, there follows an alteration in the derived demand for labor (and hence quantities of KSAs) for both types of products. These changes can be graphed in Figures 2 and 3. Recall the reduction in quantities of F purchased from y_1 to y_3 in Figure 1. Part of this change is due to the substitution of C for F and is represented by a decrease from y_1 to y_2. However, the increase in real income due to the reduction in the price of C allows a shift to indifference curve II which is tangent to budget line FC and an increase in F purchases due to the real income shift from y_2 to y_3. Note, however, that the decrease in purchases from y_1 to y_2 due to the substitution of F for C is greater than the increase from y_2 to y_3 due to the income

change. These combined effects are reflected in Figure 3 by the downward shift in the demand curve for F (represented by D_F) to $D_{F'}$. For C, the demand curve shifts upward from D_C to $D_{C'}$ due to the combined substitution and income effects.

Assume that the KSAs necessary for producing either type of system are mutually exclusive and that the following analysis applies to the entire labor demand and supply for each market. The effect of the changes in demand for F and C resulting from the price change in C leads to an increase in wages for $S_{KSA(C)}$ from W to W' as employment increases from E to E' in the computer market in Figure 3. Conversely, the wages and employment of persons with KSAs relevant to manual systems fall from W to W' and E to E' in Figure 2.

Insert Figures 2 and 3 about here

There is a greater (derived) demand for KSAs related to electronic data processing because the price-performance relationship of EDP in relation to other media has improved. In the marketplace, the KSAs of E minus E' manual filing system employees would become surplus as wages fell from W to W'. It should be noted that the KSAs are not incongruent with TDRs, there is simply an oversupply of them at the new market equilibrium. (It should also be noted that while the KSAs in each industry are GHC within the industry, they are specific to the industry. This is what creates some degree of inelasticity in their supply. This fact is also germane to our earlier discussion of individual reactions in KSA supply to secular and cyclical changes in the derived demand for labor). For E employees to remain at work given the new demand schedule ($D_{F'}$) in Figure 3, wages must be cut to W'' in Figure 4.

Compensation systems in organizations are seldom designed to accommodate this event. On the other hand, wages could be maintained at W if employment were decreased to E'' in Figure 4. This is equivalent to laying off employees while preserving wages. (Obviously, the organization will also be making some long and shortrun accommodations in its production function as labor becomes more or less expensive relative to other factors of production.)

Insert Figure 4 about here

If an organization establishes certain operating targets like profit or return on investment, then as the derived demand for TDRs falls, if it intends to continue to compete in its same market, wages must be cut or a different production technology adopted (requiring modified TDRs) to continue established performance levels. If the latter is chosen, then skills obsolescence will occur. If the former is chosen, a given set of KSAs will simply earn a lower return than previously for the employee.

All of the foregoing assumes that the organization is making the best use of the available KSAs possessed by its employees, i.e., they are employed in product and service markets where the highest returns can be achieved.

Within-Industry Effects of Product Substitution

In the example above, we demonstrated the effects of the introduction of an improvement in a product which was a substitute for another produced by a different industry. In that example, the KSAs of employees in each industry were assumed to be mutually exclusive. We will now develop an example of within industry product substitution and its effects on employment in the firm

which makes the improvement and the one for whose products the substitution is made.

Consider, for example, the market for large scale disk memory storage systems for mainframe computers. Among other suppliers have been Burroughs (Memorex Division), Control Data, IBM, and Storage Technology. Each of these firms designed, developed, and produced disk storage systems for purchase or lease by users of IBM mainframes. Over the past five years, Memorex was acquired by Burroughs after undergoing severe financial difficulties (which have again occurred within Burroughs), Control Data has abandoned the market, and Storage Technology is in Chapter 11 bankruptcy. Some of these difficulties are associated with the current weakness in computing system purchases, but others may likely possibly be attributed to skills obsolescence.

In the foregoing example, it is clear that the production functions of all suppliers are not the same. The capital available and scale of large disk memory manufacturing operations for IBM are considerably greater than any of its competitors. And, since the design of new disk storage systems depends on knowledge of the mainframe to which they will be attached, IBM has a substantial lead in their development since they know their systems interface requirements. It is also possible that the other suppliers in this market felt that their returns, while lower than IBM's, were still considerably higher than they could achieve from alternative investment and were thus willing to commit resources to it.

Notwithstanding these differences, any contribution to the reduced ability to compete that comes from the labor input must be associated with incongruence between SHC KSAs and the derived demand for TDRs imputed from the marketplace. For the set of KSAs that are GHC to the industry, the supply to

the firm is likely to be highly elastic. Thus each firm can incorporate similar KSAs into their production functions where the output is known. However, during the innovation phase for a new product, the KSAs that are associated with the TDR requirements that will ultimately be demanded reside with only one firm--the innovator. When the innovation is known, the KSA requirements will become GHC and the supply of these KSAs will expand rapidly if those with aptitudes for acquisition believe there will be high payoffs for acquisition within the time period necessary for obtaining them. Up to the point at which the innovation is known, the KSAs are SHC to the innovating firm. While the informational content of the SHCs will be hard to retain, even during the innovation phase, the managerial SHCs which led the organization to develop its particular strategy will probably not become GHC for the market because they will already be being applied to the next product strategy sequence.

Organizational Adaptations to Change and Effects on KSAs

We will consider the effects of product market substitution in two ways. First, we discuss the firm experiencing the substitution for its product, and second, the firm whose product is the new substitute.

Unless the income effect from the substitution overwhelms the substitution effect, the firm whose product remains at the same price will suffer a decline in demand. There are a variety of responses that might occur. In our exploration of responses, let us assume the following: (a) no significant differences exist in the use and efficiency of capital between organizations and no significant advantages are possible for any firm in the use of capital; (b) the producer who experienced the decline in demand was not making abnormal profits; and (c) the substitution occurs within the same general product market

(e.g., substitution of capital or consumer goods with a better price-performance ratio).

This scerario describes a situation in which the substitution results from a product attribute innovation rather than a production technology breakthrough. The firm is faced with essentially three alternatives: (a) invent a product with significantly better price-performance value than the new innovation, (b) design and produce a product which essentially duplicates the improvements of the innovative competitor, or (c) abandon the market. We will focus, in turn, on each of these alternatives from a TDR-KSA standpoint.

Invention

Invention requires the acquisition or use of skills that aren't presently utilized in the organization. When this strategy is pursued, there are no immediate firm specific TDRs. There are, however, certain aptitudes and R&D KSAs that are known to be related to past invention success in similar firms. These KSAs may be in elastic or inelastic supply depending on the overall R&D activity in the industry (and others that use close substitutes for industry-specific KSAs). If the firm has successfully invented in the past with present employees, general TDR-KSA congruence is probably available. From a competitive standpoint, choice of this strategy might turn on expected returns from this vis a vis other activities (for a general look at issues related to strategy, see Porter, 1980).

Imitation

Imitation assumes that the organization will produce a product with essentially similar performance capabilities (with, perhaps, some price advantages). This approach might frequently be pursued where a system requires

several components, where there may be a significant maintenance aftermarket, or where purchasers can be convinced to view the product as a commodity. TDRs in this situation would be altered to match those necessary to produce the imitation. The largest source of supply for the specific KSAs resides with the innovative competitor. Within the imitating organization, the employer may develop the necessary KSAs through intensive examination of the competitor's product and other development methods. In the short run, the supply of KSAs is probably very inelastic in the market, thereby requiring all employers to pay substantially higher wages to obtain them. In this case, the short run is the period of time necessary to develop the KSAs in the present work force. For the employer to adopt an imitation strategy, it must be able to affirmatively answer one of two questions. If I decide to pirate KSAs from my innovative competitor (assuming no invention barrier agreements are enforceable), can I afford the salaries necessary to induce movement given the inelasticity of supply in the market? If I decide to develop KSAs internally, will there be enough time before the next innovation is introduced for me to recoup the cost of my employee development and earn a satisfactory profit through sales of an imitative product?

Abandon the Market

Abandonment suggests that in the long run the firm expects that its investments can gain a higher return in some other endeavor. The choice of whether or not to abandon the market will depend to some extent on its ability to shed physical capital and labor necessary for its present products. This might involve a sale or a shutdown. It might also involve substantial retraining if the employer believed that employee aptitudes were sufficiently

high to acquire KSAs for a new market to provide at least the same kinds of returns that might be available in an imitation environment.

Strategies for Imposing and Avoiding Skills Obsolescence

The manner in which specific firms are organized and develop their strategies contributes to their performance (Miyazaki, 1984) and becomes part of their production functions. Successful achievement of goals (relative to other organizations) requires the design and implementation of a different (better) production function than competitors. Differences in the structuring of the labor portion of the production function are associated with job design and organizational structure (i.e., the TDRs [KSA requirements]) aspects which are idiosyncratic to the organization. To the extent that the TDRs necessary for strategy formulation and implementation are firm-specific and unknown to the market until the results of the strategy can be seen in the marketplace, skills obsolescence (i.e., a labor component within the production function that impedes the ability of the organization to compete) within the organization is entirely a result of inadequate management strategy.

There are a variety of mechanisms that firms might use to blunt the effects of innovation by competitors on TDR-KSA relationships. Some of these have to do with the relative mobility of different types of labor and the attendant possibilities of creating monopsonistic advantages for themselves.

Actual and Potential Monopsony

The recent downsizing and movement of many "rust belt" manufacturing plants is not entirely related to climatic preferences and tax rebates. The movement of a (relatively) large facility into a geographically defined labor market may allow the employer to exert monopsony power. If, for example, a

large manufacturer establishes a plant employing 1,000 operatives in a labor market of 5,000 persons, it needs initially to establish its wage rate high enough to attract employees away from other organizations. To do this, it must anticipate being able to make larger profits from the labor of employees than its already existing competitors in that labor market. Second, if the wage rate is high enough to establish monopsony (single purchaser of an input to production) power initially, and if the employer is the only employer in that industry in the geographical area, it gains actual monopsony power in the long run because of the geographical specificity of the KSAs of employees whose TDRs are related to specific products. As products change, employees have no alternative opportunities at similar wage rates so employers can afford to layoff anticipating almost full recall when business improves, and employers can invest in what would be GHC KSAs for these employees as products change because it is in a monopsony position in the geographic market. While the KSAs would be GHC in the industry, because of the geographical limits on the labor market for those KSAs, they are, practically speaking, SHC KSAs for the employer.

Potential monopsony power (Bronfenbrenner, 1956) might be gained in two ways. The first is to pay salaries that are above the rate at which the market would be cleared. For an organization to be able to do this, it must have some noncompetitive advantages in its product market or it will earn lower returns than competitors. The second is more subtle and also requires some noncompetitive advantages in the product market. If an organization is seen by labor market suppliers as one in which employment creates GHC, then choosing to work for it rather than another which only creates SHC generates returns to the individual over and above his/her salary. Consider, for example, a jobseeker

who in the computer industry. IBM has a much larger share of hardware (and some software) markets than any other supplier. Since computer operation procedures are partially dependent on the make of hardware used, gaining experience on IBM equipment creates opportunities for transferring this GHC to a larger subset of potential future employers. Further, if IBM (or another company) has a particularly good reputation for its management expertise, then gaining experience as an IBM manager may be GHC rather than SHC in the marketplace if employers believe they can improve their own management by hiring current IBM managers.

Compensation Practices to Develop KSAs

We assume that organizations design their compensation systems to influence employee or applicant behavior. These behaviors involve movement across and within the organization's boundaries, developing KSAs, and applying developed KSAs at high effort levels toward organizational goal accomplishment.

Long Run Strategy and Pay Structures. The internal labor market of the organization consists of collections of TDRs at a variety of levels of difficulty. Rather than conceiving of the organization as a pyramid, one might instead view it more as a rectangle where the breadth of TDRs is (relatively) constant as the height of the rectangle increases. Within the rectangle, however, the density of employees at each succeeding level is smaller. Thus, the TDRs require both a greater intensity of KSAs, but might also require a greater variety as well. The pay structure of the organization should be designed in such a way as to staff each of the cells in the rectangle with the correct amount and type of KSAs given the TDRs necessary for accomplishing organizational goals. The organization needs to motivate employees who have given levels of aptitudes to choose the development of those KSAs which will be

applied to TDRs which will generate the largest profit improvements for the employer. Since differentials must be known before choices can be made about which KSAs to develop, the pay structure can be considered a lead mechanism in developing employees.

Long Run Strategies and Pay Systems. Many organizations tie individual pay changes to changes in seniority and/or merit ratings. As a person's tenure within the organization increases, these changes are permanent additions to one's salary level. These methods lead to two consequences the organization must consider. First, if salaries increase more rapidly than individual productivity, then the KSAs of senior workers are more expensive than comparable KSAs possessed by new entrants to the firm. Second, if frequent retraining of employees is necessary, the more senior employee will have to either acquire new KSAs at a more rapid rate or having acquired them perform at a higher rate than new entrants for the organization to justify investments in them rather than the new entrants.

If the performance of an organization is ultimately decided by the quality of its management, and if the development of strategy requires SHC KSAs, then the organization must design ways to reward the acquisition and results from the application of appropriate KSAs for developing strategy. These must be tied into the managerial performance measures that identify success in the marketplace, probably ultimately reflected in the performance of the firm's securities (or ability to obtain resources).

Short Run Strategies and KSA Acquisition. When an organization changes production technology or produces products using different TDR designs which require altered KSAs, it makes sense to tie the level of compensation to the present demand for the KSA requirements of the job. This means that KSAs in

excess supply would be compensated at lower rates than previously and KSAs which are now needed but weren't previously should be compensated at higher rates. Employees who acquire these KSAs would then be paid at these higher rates. This approach is similar to those advocated within skill-based pay plans (Lawler, 1982) except that in this suggestion, KSAs in oversupply face decreased compensation. One could also argue that abnormal returns to KSA acquisition should go only to those who develop them most quickly. As equilibrium is being achieved, pay premiums for particular KSAs might be expected to decline.

Organizational Choices: A Model

KSAs requirements are created and destroyed routinely. The development of KSAs responds to their requirements embodied in TDRs. However, KSAs are also developed independent of the product market and may eventually become applied to products. These KSAs may be developed by entrepreneurs who expect that investment in them and their application will result in abnormal returns in the future. They may also be developed as the result of sponsors of individuals on the expectation that there <u>might</u> be some economic or social return in the future. We are not concerned in this paper about these types of KSAs except to note that unless an organization is a product innovator, it will continually be forced to react to market changes and the likely substitution of other products for those the firm produces. The development of KSAs by an entrepreneur are done on a risk basis with the expectation that their returns given the risks involved will be greater than from other KSAs for which TDRs already exist.

In making decisions about how to react to changes in the TDR-KSA equilibrium, firms must consider three interrelated aspects portrayed in Figure 5. These are the economic ability of their employees (aptitude levels and

already developed KSAs for skill acquisition), the period of time over which developmental expenditures will be recovered, and the extent of the market for the new product for which new TDRs are derived.

Insert Figure 5 about here

Employers must make decisions regarding the purchase or development of KSAs around these three issues. The employer must expect that the market will be large enough and that it will be able to obtain a large enough share of the market to get a reasonable return. It must also expect that the market for the product will have a long enough duration for the investment to pay off. This is particularly risky when the first entrant to the market may already be developing an improved product which would make the KSAs necessary for the present product obsolete. The employer must also be concerned with the economic ability of employees or applicants to acquire or possess the relevant KSAs. Where an employer lags in a particular market, especially if it has tried to develop products there, it must have some doubt as to the economic ability of its employees. New entrants to a market may have employees with high aptitude levels but little KSA acquisition knowledge for the specific market. Employers who hire in the external market must usually pay a premium if the economic ability to acquire the particular KSAs is known to the applicants. Further, new employees must have an investment in SHC KSAs before they are capable of performing in the new organization. This may be alleviated somewhat by making them a separate organizational entity.

Conclusion

There is a certain circularity to the development of skills obsolescence. Those affected by obsolescence, organizations and individuals, are victims of changes in demand in the product and service market. But at the same time, it is other organizations and individuals that are benefiting from these same changes. Ultimately novel KSAs developed or identified by entrepreneurs inside or outside of existing organizations are applied to new product development. This development results from the expectations of abnormal returns. If the application is successful the returns to developed KSAs and products fall and they become obsolete.

The present KSAs of individuals also are at risk to obsolescence even in the absence of changes in the product or service market. As KSAs necessary for production become well known, attempts to capture them mechanically will be undertaken. Machine tools, computing equipment, and artificial intelligence programs are examples of these types of capture mechanisms. Those KSAs which are most vulnerable to capture will have the lowest future return to their holders. Two choices face these individuals: (a) attempt to limit the supply of KSAs in the market to keep wage levels up (which may only spur attempts to mechanically capture the KSAs), and (b) make choices about acquiring new KSAs within their ability levels with training investment recapture periods within anticipated remaining working lives.

Unless the economic forces and consequences that lead to skills obsolescence are understood, individuals and organizations cannot make wise choices about how to respond to them in their acquisition and use of KSAs.

Footnotes

1. Human capital theory will be discussed in the section on individual choices in KSA acquisition, below.

References

Arvey, R. D. (1973) Motivational models and professional updating. In Dubin, S. S., Sheldon, H., & McConnell, J. (eds.). Maintaining professional and technical competence of the older worker. Washington: American Society of Engineering Education, 142-166.

Baltes, P. B., & Schaie, K. W. (1974) Aging and IQ: The myth of the twilight years. Psychology Today, 7(10), 35-38.

Becker, G. S. (1975) Human capital (2nd ed.). New York: National Bureau of Economic Research.

Birren, J. E., Cunningham, W. R., & Yamamoto, M. (1983) Psychology of adult development and aging. In Rosenzweig, M. R., & Porter, L. W. (eds.). Annual Review of Psychology. Palo Alto, CA: Annual Reviews, 543-575.

Bronfenbrenner, M. (1956) Potential monopsony in labor markets. Industrial and Labor Relations Review, 9, 577-588.

Campbell, J. P., & Pritchard, R. D. (1976) Motivation theory in industrial and organizational psychology. In Dunnette, M. D. (ed.). Handbook of industrial and organizational psychology. Chicago: Rand McNally, 63-130.

Dalton, G. W., & Thompson, P. H. (1971) Accelerating obsolescence of older engineers. Harvard Business Review, 49(5), 57-67.

Doering, M., Rhodes, S. R., & Schuster, M. (1983) The aging worker: Research and recommendations. Beverly Hills, CA: Sage.

Dunnette, M. D. (1976) Aptitudes, abilities, and skills. In Dunnette, M. D. (ed.). Handbook of industrial and organizational psychology. Chicago: Rand McNally, 473-520.

Dunnette, M. D., Hough, L. M., & Rosse, R. L. (1979) Task and job taxonomies as a basis of identifying labor supply sources and evaluating employment qualifications. Human Resource Planning, **2**, 37-51.

Dunnette, M. D., & Kirchner, W. K. (1958) Validation of psychological tests in industry. Personnel Administration, **21**(3), 20-27.

Ferguson, C. E. (1969) Microeconomic theory (rev. ed.). Homewood, IL: Irwin.

Fossum, J. A., Arvey, R. D., Paradise, C. A., & Robbins, N. E. (in press) Modeling the skills obsolescence process: An economic and psychological integration. Academy of Management Review.

Foster, J. E., & Wan, H. Y., Jr. (1984) Involuntary unemployment as a principal-agent equilibrium. American Economic Review, **74**, 476-484.

Glaser, A. (1985) The advantage of being first. American Economic Review, **75**, 473-480.

Holland, J. L. (1976) Vocational preferences. In M. D. Dunnette (ed.). Handbook of industrial and organizational psychology. Chicago: Rand McNally, 521-570.

Kaufman, H. G. (1972) Relations of ability and interest to currency of professional knowledge among engineers. Journal of Applied Psychology, **56**, 495-499.

Lawler, E. E., III (1971) Pay and organizational effectiveness: A psychological view. New York: McGraw-Hill.

Lawler, E. E., III (1982) Pay and organization development. Reading, MA: Addison-Wesley.

Lehman, H. C. (1963) Age and achievement. Princeton, NJ: Princeton University Press.

Levinson, D. J., Darrow, C., Klein, E., Levinson, M., & McKee, B. (1978) The seasons of a man's life. New York: Knopf.

McDowell, J. M. (1982) Obsolescence of knowledge and career publication profiles: Some evidence of differences among fields in costs of interrupted careers. American Economic Review, **72**, 752-768.

Miyazaki, H. (1984) Internal bargaining, labor contracts, and a Marshallian theory of the firm. American Economic Review, **74**, 381-393.

Pelz, D. C., & Andrews, F. M. (1966) Scientists and organizations. New York: Wiley.

Porter, M. E. (1980) Competitive strategy, New York: Free Press.

Rumberger, R. W. (1981) The changing skill requirements of jobs in the U.S. economy. Industrial and Labor Relations Review, **34**, 578-590.

Schein, E. H. (1978) Career dynamics: Matching individual and organizational needs. Reading, MA: Addison-Wesley.

Schultz, T. W. (1961) Investment in human capital. American Economic Review, **51**, 1-17.

Schwab, D. P. (1982) Recruiting and organizational participation. In K. M. Rowland & G. R. Ferris (eds.). Personnel management. Boston: Allyn & Bacon, 103-128.

Shearer, R. L., & Steger, J. A. (1975) Manpower obsolescence: A new definition and empirical investigation of personal variables. Academy of Management Journal, **18**, 263-275.

Smith, A. (1776) Wealth of nations. New York: World, 1937.

Super, D. E., Starishevsky, R., Matlin, N., & Joordan, J. P. (1967) Floundering and trial after high school. Career Pattern Study, Monograph IV. Cooperative Research Project No. 1393. New York: Teachers College, Columbia University.

Thurow, L. C. (1970) Investment in human capital. Belmont, CA: Wadsworth.

Vroom, V. H. (1964) Work and motivation. New York: Wiley.

Zelikoff, S. B. (1969) On the obsolescence and retraining of engineering personnel. Training and Development Journal, 23(5), 3-14.

Figure 1

Effects of Price Change on Product Consumption

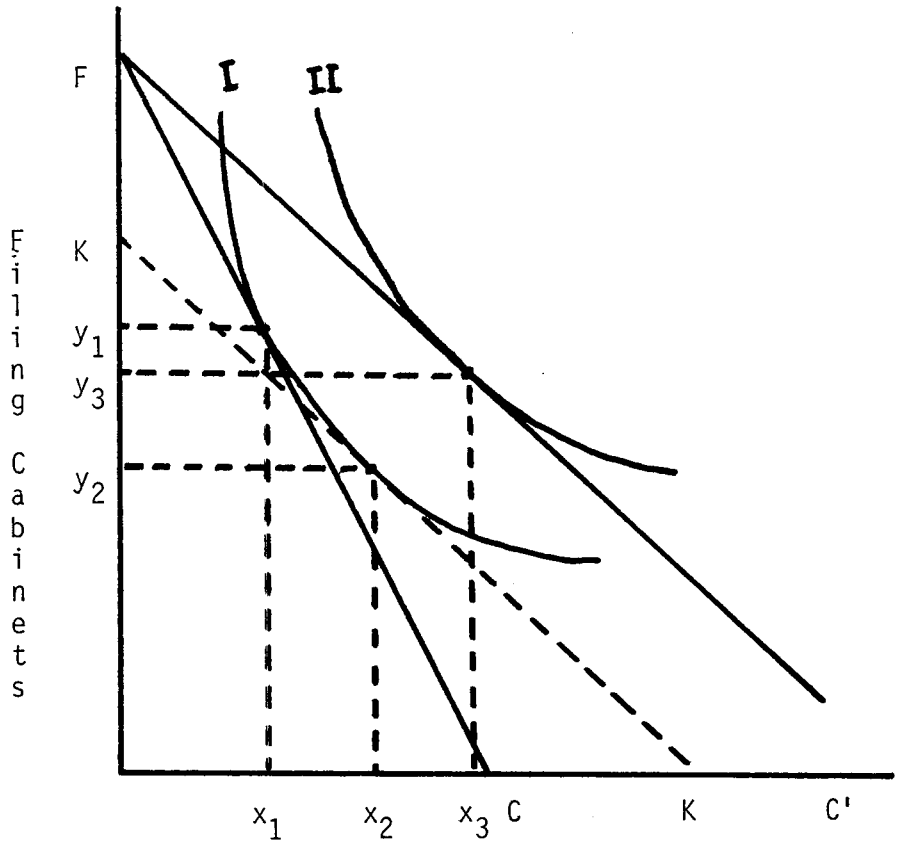

Figure 2

Wages and Employment for Filing Cabines KSAs

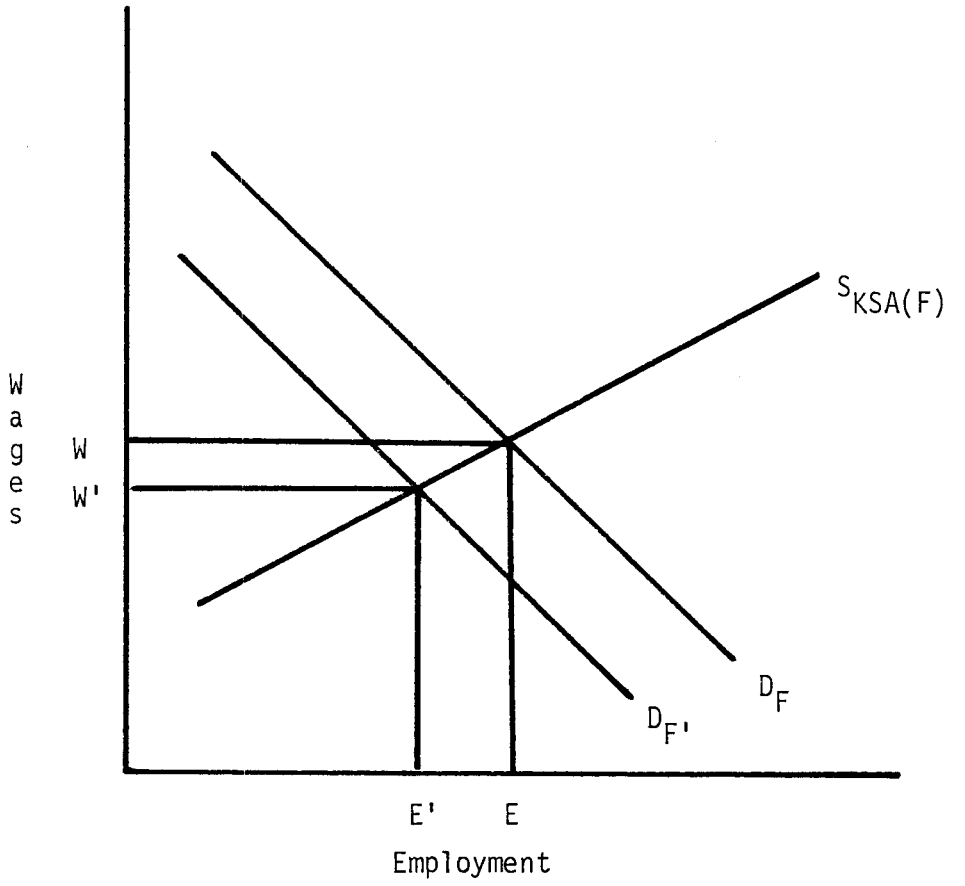

Figure 3

Wages and Employment for Computing Memory KSAs

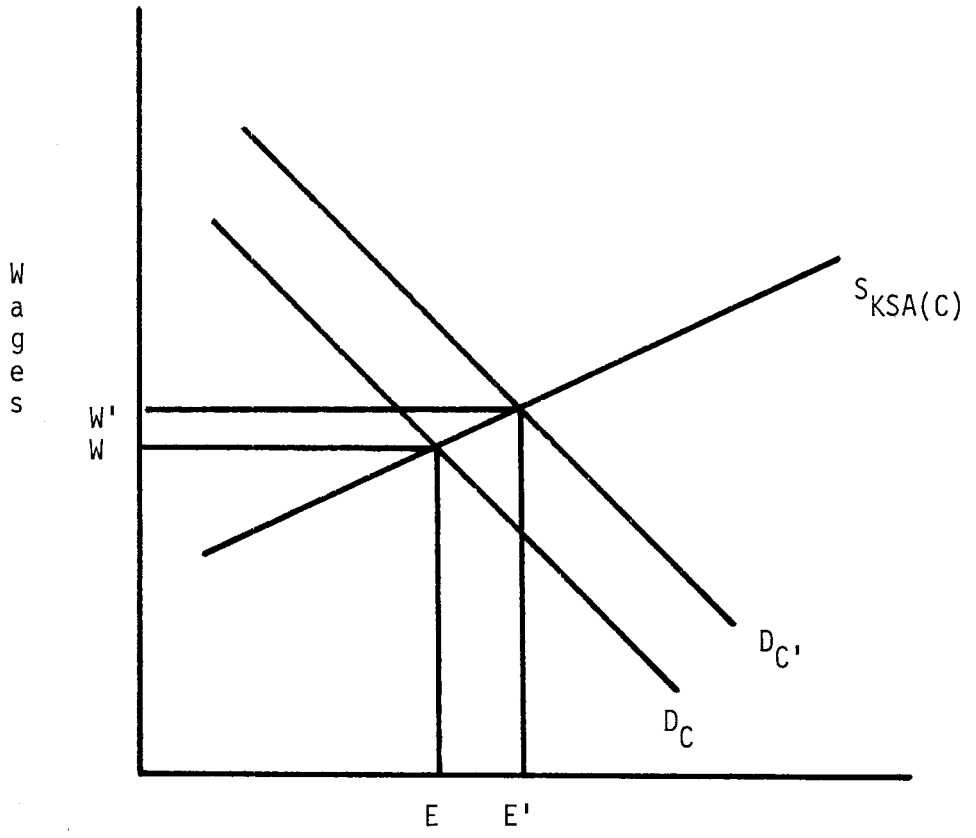

Figure 4

Wage and Employment Changes to a Decline in Demand

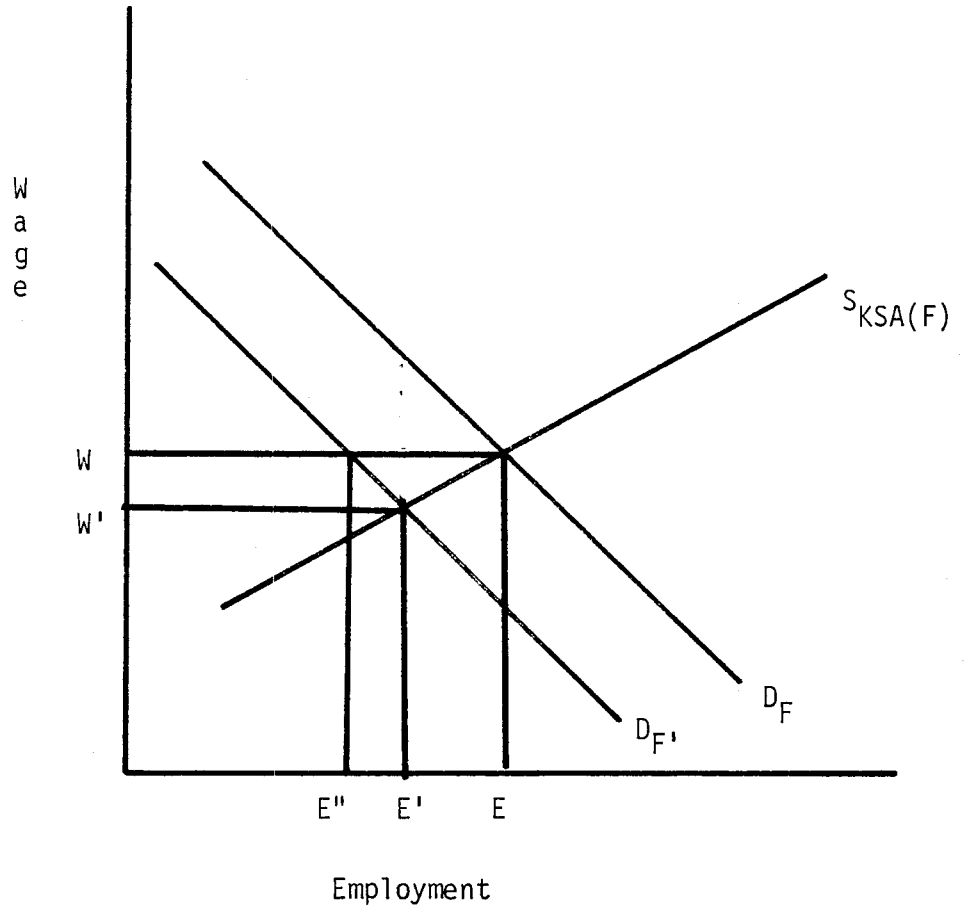

Figure 5

Factors Associated with Response to Environmental Change