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ABSTRACT

This essay attempts to forge links needed between literacy and economic activity by demonstrating analytical methods for relating the production and consumption of goods and services in an economy to the requirements for literacy among its workers. First, work force literacy is described within an economic framework. Second, economy-literacy links are demonstrated with data from a hypothetical economy, dubbed Tinkerland because its economic features are "tinkered with" during the demonstration. The links among production, consumption, employment, and literacy are shown in the economy during the "previous" period. Then the status quo of the economy is altered to show the sensitivity of literacy requirements to changes in production and consumption. Third, directions for research are established to help unravel the complex ties between the employment needs of an economy with the literacy of its workers. A technical appendix describes methods used to calculate the linkages and changes described in the section on the hypothetical economy, Tinkerland. A list of 61 references is provided. (YLB)

Requirements for Workforce Literacy: An Interindustry Model

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REQUIREMENTS FOR WORKFORCE LITERACY: AN INTERINDUSTRY MODEL

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The economy of the United States is a powerful job machine. It produced 16 million new jobs between 1982 and 1987, more than 2.5 times the number generated by six other major industrialized nations combined (U.S. Department of Labor, 1989). In 1987 alone, 3 million new jobs were created, and 2 million workers were added to the labor force. The unemployment rate dropped below 3% in some areas of the country, and the proportion of the working population rose to a record high of 61.9%. The ability of the fertile United States' economy to bear new jobs is remarkable in spite of its chronic and severe problems with federal budget deficits, unfavorable balances of foreign trade, diversion of capital to finance corporate mergers and acquisitions, and high labor costs.

The Literacy "Crisis"

Belief is widespread among government and business leaders, however, that the decaying literacy of the workforce jeopardizes continued growth of jobs, expansion of living standards, and competitiveness in the world economy. Secretary of Labor Elizabeth Dole (1989) claims that young people "simply don't have the education and skills needed to survive in today's workforce....America's workforce is...unready for the new jobs, unready for the new realities, unready for the new challenges of the 90's" (p. 1). David Kearn, Chairman and Chief Executive Officer of Xerox, charges that "American schools are flunking the job of education of the workforce" and that some high school graduates can "barely read their own diplomas" (Bureau of Labor and Management Relations, 1989, p. 10). Students who drop out of school cost the economy $240 billion in lost earnings and taxes over their lifetimes. No wonder Secretary Dole (1989) believes workforce illiteracy "is the American dream turned nightmare" (p. 3).

Literacy commonly is defined as the ability to read, write, and compute in a routine manner. The functionally literate worker is expected to exhibit interpersonal, listening, and metacognitive skills; establish and implement goals; use computers; work in teams; and solve problems in addition to other assorted requirements (Collino, Aderman, & Askov, 1988, pp. 1–2; Harmon, 1985; Imel, 1989). One of every ten adults is estimated to be illiterate, and a majority of high school seniors cannot even write a letter to seek employment or calculate their own lunch bills (see review of evidence by Forlizzi, 1989). Some analysts, such as Kozol (1985), believe that these figures underestimate the the prevalence of illiteracy in the United States.

Literacy and Work Successful job performance depends upon literacy (see reviews by Collino, Aderman, & Askov, 1988, pp. 9–10 and Sticht & Mikulecky, 1984). Literacy can also affect worker safety because of the reliance on written information to present cautions for the use of hazardous machinery, chemicals, and substances (Bruening, 1989, p. 120). To combat the problems caused by illiteracy in the workplace, three–quarters of the nation's largest employers deliver remediation of basic skills that elementary and secondary schools did not provide (Goddard, 1987).

Workforce literacy is not likely to become less important or problematic either. According to *Workforce 2000*, a government–commissioned report (Johnston, Packer, & Associates, 1987), vast changes in work and in the workforce will affect the United States' economy from now until the end of the century. In particular:

- *The structure of employment will change.*

  Service industries will experience employment growth, while employment in manufacturing industries will decline.

- *Demographic groups traditionally less likely to participate in the labor force and with less access to and result from education and training will form an increasing share of the workforce.*

  Women, blacks, and people of Hispanic or Asian origin will comprise approximately four of every five workforce entrants. Approximately 600,000 immigrants will enter the country, two–thirds of whom will want to work. Fewer young people will enter the labor force due to declining population growth rates. White males will leave the labor force in record numbers due to retirement and death.

- *Skill requirements will escalate.*

  Education and training beyond high school will become a necessity for most jobs. Demands for sophisticated language and mathematics skills will double over current levels.

Carnevale, Gainer, and Meltzer (1990) contend that the effects of technological advances and competitive necessities already are evident in demands for more competent, adaptive, and literate workers. For example, secretaries are evolving into information managers. Bank tellers market financial services and furnish portfolio consultation for individual customers. Auto mechanics work less like grease monkeys and more like computer operators. X–ray technicians are no longer merely "bone photographers." They also operate sophisticated computerized axial tomographic and magnetic resonance imaging equipment. Carnevale et al. (1990) warn, however, that skills of the new American workforce are on a collision course with the skill demands of our future economy. The sharp contrast of dismal predictions for future worker skills with expectations for more complex, more demanding jobs caused the *Wall Street Journal* to wonder in a headline, "Smarter jobs, dumber workers. Is that America's future[?]" ("*Wall Street Journal* Reports," 1990, p. R1).

Focus of Research

The Problem It is puzzling that, for all of the attention and worry that the topic of workforce literacy generates, policy–makers and educators remain insufficiently aware of the complex links between the structure of the United States' economy and the literacy it requires. What amount and kind of workforce literacy is needed to attain our nation's economic aims? How do workforce literacy requirements change as the economy changes in orderly as well as chaotic ways? How sensitive are requirements for workforce literacy in one industry to seemingly autonomous changes in another industry? Without answers to questions such as these, solutions to problems of workforce literacy could be imprecise at best, or at worst expensive boondoggles that our deficit–ridden nation can ill afford.

Our Solution In the remainder of this essay we forge links needed between literacy and economic activity by demonstrating analytical methods for relating the production and consumption of goods and services in an economy to the requirements for literacy among its workers. First, workforce literacy is described within an economic framework. Second, we demonstrate economy/literacy links with data from a hypothetical economy, dubbed *Tinkerland* because we tinker with its economic features during our demonstration. Third, we establish directions for research that would help unravel the complex ties between the employment needs of an economy with the literacy of its workers. Throughout this essay we emphasize an intuitive understanding of the approach, and we demonstrate the technical and mathematical details of our approach in an appendix to this essay.

A Limiting Assumption We deeply appreciate that the focus of workforce literacy is subservient to the promotion of literacy for "the liberation of people for intelligent, meaningful and humane action upon the world" (Kazamek, 1988, p. 473). Moreover, the notion of literacy "embraces the growth of the human spirit, recognizing that full participation in the economy will accompany such personal growth" (Fingeret, 1988, p. 5). However, ours is an entirely utilitarian approach to the issue of literacy. Rather than viewing literacy as a unalloyed social good, we treat literacy as an economic good in itself, as a commodity, as a factor of production. We do not ask how much literacy our society wants, but how much our economy requires.

Workforce Literacy in an Interindustry Framework

Structure of Production and Consumption

Origins of Structural Models Money flows. Each dollar paid to the baker for bread is spent, in turn, for salt, eggs, and flour. The mill from which the baker buys flour uses the baker's money to buy grain. A farmer grows the grain from seed, fertilizer, and fuel purchased from suppliers. The diesel fuel supplied for the farmer's tractor completes a long journey from below nomadic sands, to refineries, to supertankers, to distribution points. Banks, insurers, and other services support these transactions. Wages paid to workers throughout these complex transactions are saved or are used to purchase goods and services for household consumption. Some wages go to pay taxes. Although the purchase of a loaf of bread is but a small ripple of economic activity, ripple upon ripple creates waves in an economy that reach many industries and workers.

Early economists noticed these economic "waves." In 1756, for example, Francois Quesnay published his *Tableau Economique*, a tabular display stressing the interdependence among economic activities. Quesnay was the leader of a group of 18th century economists who became known as physiocrats. They believed in the existence of a natural order in economic activity and regarded the state's role simply to preserve property and uphold the natural order. Quesnay's original *Tableau* depicted the interdependencies among activities in the operation of a single establishment—a farm. Later, Quesnay published a modified version of the *Tableau* to represent the entire economy of his day in the form of a series of circular money flows.

Quesnay's ideas remained dormant until 1874 when Leon Walras, considered the founder of mathematical economics, published *Elements d'economie politique pure*. Walras's analysis showed the interdependence among producing sectors of the economy and the competing demands of each sector for factors of production (land, capital, labor). Walras's ideas remained at the theoretical level because he felt that, even if the data were available to implement his model, the computational problems posed by testing his ideas with actual data would be formidable, if not insurmountable.

Leontief's Pioneering Work Wassily Leontief (1936, 1941, 1946, 1951, 1953, 1966) received a Nobel Prize in economics for his work on interindustry economic analysis. In the 1930's, Leontief employed an approach, similar to those presented by Quesnay and Walras, based on observations about economic interdependence in production. However, Leontief went beyond the theoretical analyses of Walras and Quesnay by publishing a table showing the transactions between producing and purchasing industries in the United States' economy. Moreover, he provided mathematical tools necessary to derive some astoundingly useful information from the transaction table.

Leontief's method is called *interindustry analysis* because it portrays dependencies among industries. Sometimes Leontief's model is called *input–output analysis* because it shows the industrial input necessary to produce economic output. The extension of Leontief's model to the estimation of employment by industry and occupation is primarily the result of work by Bezdek (1974). In this essay we provide methods for extending the Leontief/Bezdek framework to the estimation of an economy's literacy requirements.

Leontief's model is especially useful in answering "what if" questions about the sensitivity of employment to changing economic conditions. For instance, Bezdek (1972) analyzed the employment consequences of *Counterbudget* (Benson & Wolman, 1971), which was a broad plan presented by the National Urban Coalition for reordering national expenditure patterns in the United States to emphasize social programs. Bezdek found that the *Counterbudget* proposal probably would not be politically acceptable because it would decrease employment in many occupations. Moreover, some occupations experiencing severe shortages of labor would require unrealistically large increases of workers to meet the pattern of national expenditures implied by the *Counterbudget* proposal.

Interindustry transaction tables are available for over 80 national economies. The Japanese are probably the most sophisticated users of Leontief's models. Interindustry analysis is used routinely in highly developed countries—both those that engage primarily in central planning and those that rely chiefly on market mechanisms for the allocation of resources and the distribution of income. Less developed countries use interindustry analysis to guide investments for development.

The Bureau of Labor Statistics in the United States applies Leontief's model to forecast economic and employment changes. Input–output methods are commonly used to study growth and change in regional economies. The body of research pertaining to interindustry analysis is so large that the official bibliographic reference of the American Economic Association, *The Journal of Economic Literature*, devotes a special section to input–output analysis.

Leontief's Model Leontief's model can be described in brief, non–technical terms. It starts with the observation that the chief aim of an economy is to produce goods and services for consumption. The amount of goods and services delivered directly to consumers is called *gross national output (GNP)* or, a synonym, *final demand*.

Some of an economy's output is not delivered directly to consumers. Rather, it is required by industries so that they can produce goods and services for other industries to use. For instance, cars are delivered directly to consumers, but steel, glass, plastic, and machine tools are required for car production. In this way, indirect output of industries is embodied in the goods and services ultimately delivered to consumers. Consumers do not, for the most part, buy sheet steel directly, but they receive it indirectly through their purchases of cars.

The interdependence of industries means that change in the total output of one industry will affect other industries. For instance, an increase in car production will require such other industries as steel, glass, plastics, and machine tooling to increase their output. In this way, the total output of an economy is greater than its GNP.

The fundamental relationship modeled by Leontief is that *direct output (GNP) + indirect output = total output*. Leontief calculates direct and indirect requirements for goods and services by solving a simple system of equations describing the relationships between production and consumption in an economy. As previously noted, a mathematical summary of the interindustry model and its application to the estimation of employment by industry, occupation, and literacy requirements is provided in a technical appendix to this essay.

Labor in Production

Bezdek (1974) extended Leontief's model to the estimation of employment by occupation and industry. Industries vary in the mix of capital, labor, and other industries' output they employ as input to produce their own output. In particular, industries vary in the number of workers needed to produce a unit of output. Some industries are *labor–intensive*, while others are more *capital–intensive*. Therefore, total employment in an industry is defined as the number of workers needed to produce its output.

Some industry employment is required to produce goods and services that are sold directly to consumers. Other industry employment is required to produce goods and services for other industries to be used in their own production. Therefore, some jobs in one industry depend upon the activity of other industries because of the pattern of direct and indirect requirements for goods and services in an economy.

The distribution of workers by occupation within an industry is termed its *industry employment profile* and depends upon the requirements for a particular mix of human capital in the industry's production process. For instance, the employment profile in the retail shoe sales industry differs remarkably from the profile for the steel fabrication industry.

Just as total employment within an industry depends upon direct and indirect requirements for the industry's output, so does the employment by occupation within an industry. Changes in an industry's output not only affect the level of employment by occupation in the industry itself, but also in other industries. As a result of these changes, the occupational distribution for an entire economy can shift. Moreover, changes in technology and substitution of technology for workers in production can affect industry employment profiles and, in turn, the occupational distribution of the entire economy.

Bezdek extends Leontief's model to estimate direct and indirect requirements for employment by industry and occupation implied by a particular level and distribution of GNP in an economy. Likewise, analysts can examine changes in employment by occupation dictated by changes in the structure of production and consumption.

Literacy in Production

An aim of most taxonomies of occupations is to classify workers into homogeneous groups that perform similar tasks and use similar skills in production. The problem of classifying people uniquely by the nature of the work they perform is intractable because there is no natural taxonomy of occupations. Moreover, defining the role of literacy in production is difficult because most occupational classification systems lack information about job content (cf. Passmore & Marron, 1982). For instance, all workers under the classification "plumber" should do the same work. If occupational classifications fulfilled this aim, then planners and analysts could use occupational titles to simply summarize the functional requirements for workers employed with this occupational title as well as the functional capabilities of the workforce.

The correspondence between occupational titles and functional requirements for workers is weak. Most existing occupational classification systems have been social defined—that is, these systems were developed to classify workers along one or two dimensions and to conform with specific data collection and reporting needs. This attribute of occupational classification systems makes them arbitrary, although useful for the task at hand (cf. Edwards, 1943, and Roe, 1956, for a contrast between socioeconomic and psychological approaches to occupational classification). Many frequently–used occupational classification systems such as the *Dictionary of Occupational Titles* (US Department of Labor, 1978) or US Census of the Population and Housing (US Department of Commerce, 1971, 1977) are characterized by some labor market analysts as unreliable and outdated, and they cover incompletely the wide range of jobs performed in the US economy (Crites, 1969, chap. 2; Miller, Treiman, Cain, & Roos, 1980; Scoville, 1969; Spenner, 1983, 1985). The result is that "the educational planner is faced with occupational and educational classification systems which discourage a systematic matching of supply and demand data" (Evans & Marshall, 1975, p. 1).

One consequence of these inadequacies is that controversy continues about the type and amount of education and training needed for successful performance in occupations. Therefore, determination of whether skill requirements for work are increasing or decreasing is difficult. Bailey (1990, pp. 4–8; 39–42) reviews the historical debate about whether economic and technological improvements in an economy increase or decrease skill requirements. For example, Bailey notes that, starting from vastly different ideological premises, Braverman (1974) and Levin (1987) both conclude that a prime motivation for technological change was to limit the need for skill and initiative of workers in production. Also, many analysts, such as Berg (1970), Freeman (1976), and Rumberger (1981), believe that Americans are overeducated for the demands of the workplace.

On the other hand, optimistic ideas about growth of skill requirements have influenced, and continue to influence, many policy–makers. The leitmotif for this side of the debate was exemplified by Walker (1958) in a study of technological change in a steel mill:

> What was called for in the new mill was skill of a different *kind*: skills of the head rather than the hand, of the logician rather than the craftsman, of nerve rather than muscle, of the pilot rather than the manual laborer, and of the maintenance man rather than the operator. (p. 113)

More recent studies by Adler (1986) and Hirschorn (1988) continue with Walker's optimism, and the highly influential *Workforce 2000* report (Johnson, Packer, & Associates, 1987) is responsible for the current "crisis" drawn from the perceived mismatch of the skill requirements of the US economy with the skills of the emerging workforce.

In light of the uncertainty and controversy about general education and training requirements for the emerging workplace, statements about the economic and social crises created by illiteracy of the workforce seem unsupportable and almost glib. Although firms invest in literacy education and literacy levels are relatively low, the amount of literacy needed for production remains unknown. The situation is like not knowing how many AIDS cases exist as a basis for deciding the amount and kind of medical and support services needed, or like knowing that a tornado touched down without knowing where and with what effect on person or property. It is no basis for allocating public resources to eradicate a problem.

Several solutions to the inadequacies of occupational classifications are available. Using information contained in the US Department of Labor's *Estimates of Worker Traits for 4,000 Jobs* (US Department of Labor, 1956), Eckaus (1964) first translated the levels of "general educational development" into years of education and "specific vocational preparation" into months of training time necessary for a worker to acquire the knowledge and abilities for average job performance. Eckaus then used data from the 1950 census of the population to estimate years of schooling and period of training in major industry groupings in 1950. Eckaus's estimates, although interesting, have limited usefulness due to the heterogeneity of occupations employed within the same industry.

Scoville (1966, 1969) extended Eckaus's work by estimating the levels of education and training required by all occupations in the US Bureau of the Census classification system applied during 1956. Slight modifications of Scoville's method of estimation are still applied by the US Department of Labor to estimate skill requirements for US jobs. The six skill levels portrayed in Table 1 define skill requirements in US Department of Labor occupational employment projections, including those developed for *Workforce 2000* (Johnson, Packer, & Associates, 1987). Applying these definitions, Johnson, Packer, & Associates (1987) believe that occupations of the future will require higher skill levels. In 1984, for instance, 6% of all jobs required workers with the two highest skill levels; for jobs likely to be created between 1984 and 2000, that figure will rise to 13%.

Although the US Department of Labor's approach treats the demand for "skills" within a comprehensive economic framework, it assumes that various levels of educated labor cannot substitute for one another. Studies using production function analysis have demonstrated the substitutibility among levels of educated labor in production. Some studies show the substitutibility of labor and capital in production. On the other hand, some studies treat these factors as complements in production. In addition, labor and occupational mobility data from the 1970 Census fit to the Bureau of Labor Statistics model of occupational supply structure (see Sommers, 1974) by Sommers and Eck (1977) show the remarkably varied sources of entry into most occupations.

Some major, unanswered questions from the US Department of Labor's framework include: (a) to what extent are occupations (skills levels, educational levels, credentialed and non–credentialed labor, etc.) substitutes for one another? and (b) to what extent are non–labor inputs (technology, capital) substitutes for labor inputs to production? In general, are choices among labor inputs or between labor

Table 1
US Department of Labor Examples of Six Language and Mathematical Skill Levels Needed for Job Performance

Skill Level	Language Skill	Mathematical Skill
6	Reads literature, book, and play reviews, scientific and technical journals, financial reports and legal documents. Writes novels, plays, editorials, speeches, critiques.	Advanced calculus, modern algebra, and statistics.
5	Same as 6, but less advanced	Knows calculus and statistics; econometrics
4	Reads novels, poems, newspapers, manuals, thesauri, and encyclopedias. Prepares business letters, summaries and reports. Participates in panel discussions and debates. Speaks extemporaneously on a variety of subjects.	Is able to deal with fairly complex algebra and geometry, including linear and quadratic equations, logarithmic functions and deductive axiomatic geometry.
3	Reads a variety of novels, magazines, and encyclopedias, as well as safety rules and equipment instructions. Writes reports and essays with proper format and punctuation. Speaks well before an audience	Understands basic geometry and algebra. Calculates discount, interest, profit and loss, markup, and commissions.
2	Recognizes meaning of 5,000–6,000 words. Reads at a rate of 190–215 words per minute. Reads adventure stories and comic books, as well as instructions for assembling model cars. Writes compound and complex sentences with proper end punctuation and using adjectives and adverbs.	Adds, subtracts, multiplies, and divides all units of measure. Computes ratio, rate, and percent. Draws and interprets bar graphs.
1	Recognizes meaning of 2,500 (two- or three-syllable) words. Reads at rate of 95–120 words per minute. Writes and speaks in simple sentences.	Adds and subtracts two-digit numbers. Does simple calculations with money and with basic units of volume, length, and weight.

Source: "Wall Street Journal Reports," 1990, p. R8.

vs other inputs price sensitive? One way to provide answers to these questions using interindustry methods is through analysis of capital/labor intensities and industry employment profiles over time. Methods originally developed by Gowdy and Miller (1987) for analysis of the effects of technological and demand change in energy use might prove applicable to the problems of estimating substitutibility of labor inputs over occupations and with technology. The role of substitution in labor markets in response to price changes is an unknown factor affecting the planning of education for work in most active, mobile economies. The US Department of Labor's classification of skill requirements shown in Table 1 is applied in the demonstration in the following section of this essay, even though it leaves a number of fundamental questions about the role of literacy in production unanswered.

Production, Consumption, Employment, and Literacy in Tinkerland: *Demonstration of Economic Linkages and Change*

We cast a hypothetical economy of an economic region, which we call *Tinkerland*, into an interindustry economic framework in this section. We describe this economy during two economic periods: a *previous* period and a *current* period. First, we show the links among production, consumption, employment, and literacy in the economy during the previous period. We use US Department of Labor skill levels defined in Table 1 to represent literacy levels. The interindustry analysis methods used to make these linkages are similar to those used to project employment and skill requirements in *Workforce 2000* (Johnson, Packer, & Associates, 1987). Second, we alter the status quo of the economy to show the sensitivity of literacy requirements to changes in production and consumption. The methods we use to study the effects of economic changes have been applied previously within an interindustry framework, but not to the analysis of economic determinants of skill and literacy requirements. The technical appendix to this essay describes methods we used to calculate the linkages and changes described in this section.

The *Tinkerland* economy contains five industries: mining; manufacturing; construction; business and repair services; and transportation. Workers are employed in six occupations: managerial and professional specialty occupations; technical, sales, and administrative support occupations; farming, forestry, and fishing occupations; precision production, craft, and repair occupations; and operators, fabricators, and laborers. There are six destinations for the output of goods and services produced by the five industries: households; state government; defense expenditures by the federal; government; non–defense expenditures by the federal government; inter–regional exports; and foreign exports. Obviously, actual economies have more industries, occupations, and categories of final demand than the *Tinkerland* economy, but the procedures used to analyze the linkages in a larger economy are the same as we use to dissect the *Tinkerland* economy.

Linkages

Production and Consumption Transactions among *Tinkerland* producing and purchasing industries are shown in Table 2 for a "previous" economic period. The linkages among production, consumption, employment, and literacy are demonstrated using data from the previous period. Hypothetical data from a "current" economic provide are used in our subsequent analysis of the effects of economic change.

Table 2 also shows the distribution of industry output over categories of final demand for the previous period. Total final demand is presented in the second to last column of Table 2. The total output of the *Tinkerland* economy during the previous period was $500 billion. Its gross regional product (GRP) during the previous period, the value of goods and services delivered to meet final demand, was $202 billion. Therefore, the total regional output of *Tinkerland* actually was more than two times its GRP. Households received 40.1% of *Tinkerland's* GRP. Almost 12% went to state government, 5.4% to federal defense expenditures, 13.9% to federal non–defense expenditures, 21.3% to inter–regional exports, and 7.4% to foreign exports.

Interindustry transactions in the processing sector of Table 2 show, for example, that

Table 2
Previous Production and Consumption in the Tinkerland Economy (billions $)

Producing Industry	Purchasing Industry: Mining	Manufacturing	Construction	Business & Repair	Transport	Final Demand: Households	State	Federal: Defense	Federal: Non-Defense	Inter-Regional Exports	Foreign Exports	Total Final Demand (GNP)	Total Output
Mining	21	0	9	3	0	30	10	5	0	20	2	67	100
Manufacturing	1	8	7	29	0	25	5	2	0	15	8	55	100
Construction	3	20	0	50	7	5	2	4	4	3	3	20	100
Business & Repair	31	2	38	0	3	12	2	0	11	1	0	26	100
Transport	10	25	26	1	4	9	6	0	13	4	2	34	100

Source: Hypothetical data used in simulation prepared by Passmore (1990).

mining sold $9 billion worth of goods and services to construction; mining purchased $21 billion of its own output. Mining was the largest contributor to *Tinkerland* GRP, accounting for $67 billion of the $202 billion (33.2%) that went to final demand. Also, mining has the highest percentage (67%) of its total output that went to final demand among the five *Tinkerland* industries.

Labor Force and Employment *Tinkerland* industries vary in the amount of labor they need to produce a dollar's worth of output. Labor input coefficients for *Tinkerland's* five industries shown below are calculated by dividing the total number of workers (in thousands) employed in each industry (derived through survey or other means) by $100 billion (each industry's total output from Table 2):

Industry	Employment	Labor Input
Mining	600	.0006
Manufacturing	400	.0004
Construction	300	.0003
Business & Repair	100	.0001
Transport	500	.0005
Total	1,900	.0019

Employment by Industry and Occupation The distribution of *Tinkerland* employment by industry and occupation during the previous economic period is shown in Panel I of Table 3. The pattern of employment shown in Panel I was required to produce the amount and kind of final demand specified in Table 2. Occupational employment varied from a high in technical, sales, and administrative support occupations, in which approximately one-fourth of all workers were employed, to farming, forestry, and fishing occupations, which employed only one in every 20 *Tinkerland* workers. Mining contributed the greatest proportion of industrial output to total *Tinkerland* output during the previous period; likewise, mining accounted for the most employment—600,000 workers— of any of the five industries. Business and repair services had the lowest number of workers in the *Tinkerland* economy during the previous period.

Industry employment profiles vary because industries required different mixes of occupations to produce goods and services. For example, business and repair service and construction industries had a higher percentage of their total industrial employment in managerial and professional specialty occupations than did other industries. Operators, fabricators, and laborers composed a greater proportion of the workforce in mining and manufacturing industries than in other industries. The interested reader can calculate the occupational staffing pattern of each industry by dividing the number employed within each occupation in an industry by the industry's total employment.

Table 3

Interindustry Employment Dependency The dependency of occupational employment on the amount of total output of each industry is striking. Entries in panel II of Table 3 show the number of jobs in each occupation that were generated *by* each industry. Comparison of panels I and II indicates that, for instance, although mining employed 120,000 people in managerial and professional specialty occupations (panel I), the industrial output of mining delivered to industries and to final demand generated jobs for 169,600 people in managerial and professional specialty occupations (panel II). In other words, mining activity generated employment for 49,600 more workers in managerial and professional specialty occupations in other industries than it employed itself.

In terms of the entire *Tinkerland* economy during the previous period, mining was a big player—it employed 600,000 people (sum over the mining row in panel I of Table 3), almost one-third of all *Tinkerland* workers. But, even more important is that mining production created jobs for 819,000 workers (sum over the mining row in panel II of Table 3) over all industries in the *Tinkerland* economy. The following comparison of the employment (in thousands) generated directly and indirectly by each industry isolates sectors of employment dependencies in the *Tinkerland* economy during the previous period:

Industry	Direct	Indirect + Direct
Mining	600	819.0
Manufacturing	400	455.9
Construction	300	191.1
Business & Repair	100	223.9
Transport	500	210.1
Total	1,900	1,900

Previous Occupational Employment Generated Within and By Tinkerland *Industries (000's)*

Producing Industry	Occupation: Managerial/ Professional Specialty	Technical/ Sales/ Administrative	Service	Farming/ Forestry/ Fishing	Precision/ Craft/ Repair	Operators/ Fabricators/ Laborers
			I. Generated Within Industries (Direct)			
Mining	120	120	60	30	90	180
Manufacturing	40	120	80	10	30	120
Construction	90	90	30	22.5	30	37.5
Business & Repair	30	20	10	10	5	25
Transport	100	150	100	40	10	100
Total	380	500	280	112.5	165	462.5
%	20.0%	26.3%	14.7%	6%	8.7%	24.3%
			II. Generated By Industries (Indirect)			
Mining	169.6	188.2	98.4	46.5	96.9	219.4
Manufacturing	72.3	134.1	82.7	21.7	30.4	114.7
Construction	45.5	53.9	26.4	13.1	15.1	37.1
Business & Repair	49.6	61.3	32.5	14.8	16.5	49.2
Transport	43	62.5	40	16.4	.61	42.1
Total	380	500	280	112.5	165	462.5
%	20.0%	26.3%	14.7%	6%	8.7%	24.3%

Source: Calculated from hypothetical data used in simulation prepared by Passmore (1990).

For approximately every 3 workers employed in mining, need was generated for at least one other worker in the *Tinkerland* economyduring the previous period. A remarkable finding is that business and repair service industries employed the lowest number of workers in the *Tinkerland* economy, but more than two workers in all industries are employed for every worker in the business and repair service industries. Mining, manufacturing, and, especially, business and repair service industries created jobs outside their own industries. Obversely, the total industrial outputs of transportation and construction industries could only directly support the employment of approximately one of every two of their workers, and total employment in these industries, therefore, depended heavily upon the activity of the three other *Tinkerland* industries.

The dependence of employment in any single *Tinkerland* occupation on interindustry transactions can be demonstrated. For example, the interindustry pattern of employment for service occupations keyed to interindustry activity is shown in the following matrix:

$$\begin{vmatrix} 53,580 & 12,147 & 7,955 & 3,868 & 20,842 \\ 1,581 & 51,638 & 5,910 & 1,026 & 22,526 \\ 2,200 & 4,827 & 8,433 & 1,223 & 9,694 \\ 2,273 & 10,366 & 6,394 & 3,583 & 9,915 \\ 366 & 1,022 & 1,307 & 298 & 37,024 \end{vmatrix} .$$

The rows of this matrix are producing industries, and the columns are purchasing industries. This matrix shows how employment in a single occupation in a producing industry depends upon the activity of a purchasing industry. Over one–half of employment in service occupations was generated solely from the production of mining, manufacturing, and transportation goods and services for these industries' own consumption [{(53,580 + 51,638+ 37,024) + 280,000} x 100]. Transportation's sales to mining (row 5, column 1) and to business and repair services (row 5, column 4) created less than 1% of all employment in service occupations [{(366 + 298) + 280,000} x 100]. Mining's sales to transportation (row 1, column 5) and manufacturing's sales to transportation (row 2, column 5) accounted for about 15% of all service occupation employment [{(20,842 + 22,526) + 280,000} x 100]. Other *Tinkerland* occupations exhibit dependencies on interindustry transactions that can be revealed through similar matrices.

Employment by Literacy Skill Level Shown in Table 4 is the employment required directly and indirectly by literacy skill level and industry in the *Tinkerland* economy during the previous economic period. The distribution of skills by occupation is not the result of calculations in our adaptation of the interindustry model (nor would it be a product of any interindustry analysis), so this table is merely descriptive. Rather, this distribution would be derived either from an independent measurement of worker skills to reflect current literacy levels or from a definition of desired literacy levels for production. Calculation of employment figures shown in Table 4 requires information about the distribution of worker literacy skills for occupations within each industry. The distribution of literacy skill requirements by industry are aggregated over occupations. The 30 tables showing the distribution of skills within each industry and occupation intersection in the *Tinkerland* economy are available from the first author.*

Table 4 demonstrates that, as with occupational employment in Table 3, production in one *Tinkerland* industry can affect literacy skill levels required in other industries. For instance, Production in the Business and Repair industry uses 4,000 workers at Skill Level 6. However, its activity generates jobs for 24,700 workers at Skill Level 6.

Policy Uses Results of descriptive interindustry analysis of the *Tinkerland* economy have value for formation and analysis of policy for employment, education, and training. On the employment side, information in Table 2 and Table 3 clearly links production, consumption, and employment in *Tinkerland*. In particular, panel II of Table 3 highlights industrial sectors from which investments in growth and development might yield a high return of jobs. In the education and training dimension, information in panel I of Table 3 shows the demand for occupations to which education and training institutions might supply labor (this analysis does not, however, treat the problem of describing occupational supply). Panel II of Table 3 shows how increases in industries, seemingly unrelated to target industries of the training institutions, affect the demand for occupations to which these institutions supply labor. Most importantly, requirements for workforce literacy are linked in Table 4 to production and consumption to make the interindustry dependencies of worker literacy explicit. From Table 4, it is possible, for example, to determine how efforts to develop one industry will affect literacy requirements in other industries.

Change

In this section of this essay, we illustrate the sensitivity of literacy requirements by industry to selected changes in production and consumption in the *Tinkerland* economy.

Components Changes in the functioning of an economy that can affect employment occur in five fundamental ways—one way related to changes in consumption and four involved with changes in production. Each of these types of changes affects employment and, in turn, the requirements for literacy among workers.

Consumption drives the entire economy. It is the *raison d'être* for production and, ultimately, employment. Changes in consumption reveal changes in the demand for goods and services in an economy. These changes are manifest in reallocations of the amount and distribution of total GNP. Redistribution of industrial output among GNP categories might seem a tempting way to change employment. However, changes in the destination of industrial output, without

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Table 4
Previous Employment in Producing Industries By Skill Level Generated Within and By Tinkerland *Industries (000's)*

Producing Industry	Skill Level[a] 6	5	4	3	2	1
			I. Generated Within Industries (Direct)			
Mining	30	72	180	120	120	78
Manufacturing	40	100	120	40	40	60
Construction	60	90	30	42	48	30
Business & Repair	4	17	30	20	15	14
Transport	40	75	100	175	75	35
Total	174	354	460	397	298	217
%	20.0%	26.3%	14.7%	6%	8.7%	24.3%
			II. Generated By Industries (Indirect)			
Mining	58.7	125.6	219.4	168.6	147.4	99.5
Manufacturing	47.9	102.8	113.7	78.7	56.9	56
Construction	24.7	43.3	35.6	38	29.4	20
Business & Repair	24.5	48.4	49.4	43.2	32.8	25.6
Transport	18.2	33.9	41.9	68.5	31.5	15.9
Total	174	354	460	397	298	217
%	20.0%	26.3%	14.7%	6%	8.7%	24.3%

Source: Calculated from hypothetical data used in simulation prepared by Passmore (1990).

[a] See definitions in Table 1.

increasing total industrial output, do not increase industrial employment. For instance, implementation of a policy to export more goods and services does not increase employment unless *more* goods and services than the economy is producing are required to fulfill the policy objective.

The production sector of an economy responds to demands for consumption through the amount and use of resources it allocates. Four changes in the structure of production can occur to change output delivered to GNP or to maintain the level of output with more efficient use of resources. First, changes in patterns of interindustry transactions can result from substitution among industrial inputs to purchasing industries. Second, labor productivity of producing industries can change as a result of capital/labor substitution or efficiencies yielded from capital/labor complementarities. Third, industrial employment profiles can change due to changes in the pattern of skills needed in production. And, fourth, the literacy skill profiles of workers within occupations and industries can change due to changes in the job content and technology.

Effects on Literacy Requirements

For simplicity of presentation, we limit our demonstration of the effects of economic changes to three of five fundamental economic changes that are possible. Also, we could show more detailed results of these changes—for instance, for all occupations and generated within and by

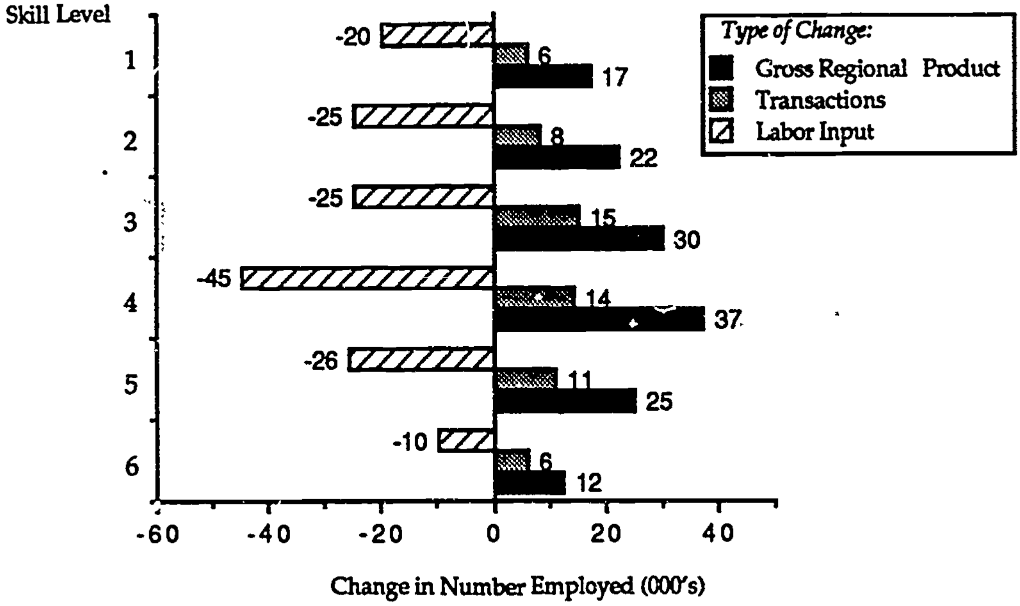

Figure 1. **Economic Change and Literacy Requirements in Tinkerland**

industries. Dissected in Figure 1 are the effects of three changes in production and consumption on literacy skill requirements in the *Tinkerland* economy between previous and current economic periods.

The following economic scenario generated the changes shown in Figure 1:

- *Gross Regional Product (GRP).*

  Amounts of total mining, manufacturing, transportation outputs delivered to final demand, or GRP, increase by 10%, 10%, and 8%, respectively, between previous and current economic periods. The GRP categories to which this new output is allocated do not affect employment or literacy requirements.

- *Interindustry transactions.*

  Amounts of mining output purchased by manufacturing and transportation industries increase by 10% and 6%, respectively, between the two economic periods. These changes in interindustry transactions reveal changes in the production functions for these two industries

- *Labor inputs.*

  The labor input coefficient for mining decreases almost 17% from 0.0006 to 0.0005; the coefficient for manufacturing drops 12.5% from 0.0004 to 0.00035 These changes reflect increases in industrial productivity that result in more industrial output per worker.

The changes between the previous and current economic periods simulated in Figure 1 for the *Tinkerland* economy result in two general patterns. First, the changes made in GRP and interindustry transactions increase employment. Second, the changes made in labor input coefficients decrease employment. The net effect of these three changes taken together are positive for all literacy skill levels. For example, changes made in the *Tinkerland* economy result in a net increase of 3,000 workers requiring literacy at work described by Skill Level 1. Changes in GRP and interindustry transactions increase employment in Skill Level 1 by 6,000 and 17,000 workers, respectively, while changes in labor inputs lead to a loss of 20,000 workers.

For the entire *Tinkerland* economy, changes in GRP and interindustry transactions increase employment by 196,000 workers, but 151,000 workers are lost due to changes in labor productivity. A net gain of 45,000 jobs is produced by these changes. A major assumption in this simulation is that the economy does not use increases in labor productivity to produce more output with the same number of workers. If this alternate use of increases productivity occurs, these jobs are not lost.

Future Research Directions

In this essay we described current concerns about workforce literacy in the US economy and the need for a more complete understanding of the links between the economy and literacy. We outlined an economic model, fashioned by economist Wassily Leontief, called the *interindustry model*, that exposes the links among production, consumption, employment, and literacy, and we demonstrated the application of this model to the specification of workforce literacy requirements in a hypothetical economy. A technical appendix to this essay describes the mathematical and computational details of our work and offers the data and computing program necessary to replicate and extend it.

Our plans are to adapt the economic approach applied in this essay to publicly-available interindustry data about the entire US economy that undergirded the *Workforce 2000* report (Johnson, Packer, & Associates, 1987) that we recently acquired from the US Department of Labor (1989). This will allow tests of our ideas with a "live" (at least the last time we were looking) economy. To implement our approach, however, research is needed on such matters as substitution of inputs to production, analysis and aggregation of workplace literacy requirements, and the addition of economic rigor to our approach.

Substitution The approach taken in this essay is to assume that no substitution exists between labor and non-labor inputs and between types of labor. In fact, though, substitution is a characteristic of labor markets (Berg, 1970; Bowles, 1969; Dougherty, 1971; Parnes, 1968). Unless methods for incorporating the responsiveness of labor demand to factor prices is included in our model, our approach will fail to mirror the functioning of actual labor markets.

Analysis Any analysis of workforce literacy must start with a functional, useful, and tractable definition of literacy in the workplace. The analysis we present in this essay *accepts* a definition of workforce literacy for expository purposes. However, the US Department of Labor definition (shown in Table 1) may be too vague and general for use in designing education and training for workforce literacy. In addition, a fine analytical line exists between description of current literacy skill levels of the workforce that are *used*, however ineffectively, in production and the skills that are *needed* for production. Geroy and Erwin (1988) report the design and validation of the *Skills Needs Assessment Method* (SNAM) for identifying requirements for procedural, technical, general, and systems knowledge and for basic skills. SNAM, developed for firm– or plant–level analyses, might be adaptable to economy–wide estimation of workforce literacy needs after some attention is focused on the generalizability of SNAM findings over firms and industries.

Rigor Our approach in this essay is fundamentally a descriptive accounting method for auditing and decomposing the linkages and changes in our production, consumption, employment, and literacy in our hypothetical economy. We fail to apply any sound economic theory to base our choices about whether, for instance, to believe that an economy will produce more total output if labor productivity increases, or whether, say, increases in opportunities for work actually result in more workers offering their labor in the market. Of course, more analytical models of economies exist (cf., Dervis, DeMelo, & Robinson, 1982; Treyz, Friedlaender, & Stevens, 1980; Treyz, Greenwood, Hunt, & Stevens, 1988) and could find application in our efforts.

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Technical Appendix:

SPECIFICATION OF AN INTERINDUSTRY MODEL FOR DEMONSTRATING REQUIREMENTS FOR WORKPLACE LITERACY

The technical details of the theory of interindustry models and their application to the description of workplace literacy requirements are specified in this technical appendix. Our presentation follows conventions of mathematical notation found commonly in the vast literature on interindustry models.

The fundamental theory underpinning our description of workplace literacy requirements is based on the work of Wassily Leontief (1936, 1941, 1946, 1951, 1953, 1966), who was awarded a Nobel Prize in economics for his pioneering effort on interindustry economics. Extensions of Leontief's model to the estimation of employment by industry and occupation is primarily the result of work by Bezdek (1974). Passmore (1979, in press) describes the use of Leontief/Bezdek models in planning education for economic development and employment. We merely expanded Bezdek's work to problems of (a) estimating direct and indirect functional skill requirements for workers within occupations and industries and (b) accounting for employment changes due to changes in production and consumption.

Theory

Structure of Production and Consumption

Consider an economy with n industries, characterized as I producing industries and J purchasing industries ($I = J = n$). Let **X** define a square n-order matrix of interindustry transactions with elements x_{ij} denoting the dollar value of output of producing industry i purchased by industry j. Diagonal elements of **X** contain the amount of output of industry i that it purchases to produce its own output.

Industrial output that is not used for further production is consumed. Let **y** indicate an n-length vector containing the dollar value of output from each of the i producing industries that goes solely to meet total final demand for consumption of goods and services. The sum over elements of **y** equals the total GNP of the economy.

The amounts of total GNP consumed among U categories describing personal consumption expenditures, gross domestic business investment, net exports, and government expenditures are shown in **q**, a u-length vector. Let **P** define an n-by-u matrix showing the percent distribution of the output of n producing industries that goes to final demand over u GNP categories. Each column of **P** sums to 100% because it shows the percent distribution of all goods and services delivered to a GNP category. Total final demand is reproduced by

$$y = Pq,\qquad (1)$$

and

$$G = PQ,\qquad (2)$$

where is $\mathbf{Q}$ is a diagonal matrix formed from $\mathbf{q}$ and G is an n–by–u matrix with elements g_{iu} denoting the dollar value of industry i output that is not purchased by other industries in the processing sector of the economy, but goes directly to GNP expenditure category u. Of course, the sum of $\mathbf{G}$ over u categories yields $\mathbf{y}$.

Let $\mathbf{x}$ indicate an n–length vector with elements x_i denoting the total output of industry i equal to

$$\mathbf{x} = \mathbf{X} + \mathbf{y}.\qquad (3)$$

The proportion of industry i output sold to industry j, or a_{ij}, is computed from x_{ij}/x_j. Let $\mathbf{A}$ represent an n–by–n square matrix of fixed, homogeneous, and linear technical coefficients containing elements a_{ij}. Now, equation (3) is rewritten as:

$$\mathbf{x} = \mathbf{Ax} + \mathbf{y}\qquad (4)$$

Rearrangement of equation (4) to state interindustry transactions and total output in terms of final demand yields:

$$\mathbf{y} = \mathbf{x} - \mathbf{Ax}.\qquad (5)$$

Introduction of $\mathbf{I}$, an n–by–n identity matrix, allows equation (5) to be arranged

$$\mathbf{y} = (\mathbf{I} - \mathbf{A})\mathbf{x}$$

and, then, solved for $\mathbf{x}$ through:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{y},\qquad (6)$$

where $(\mathbf{I} - \mathbf{A})^{-1}$, which shows how much $\mathbf{x}$ must change to increase $\mathbf{y}$ by one dollar. $(\mathbf{I} - \mathbf{A})$ is constrained by definition to contain no negative entries, but may hold zero entries; therefore, $(\mathbf{I} - \mathbf{A})$ is commonly non-singular.

Labor in Production

Let Θ denote an n–by–n diagonal matrix of labor input coefficients indicating the number of workers needed to produce one dollar's worth of total industrial output. Assuming that industry output is proportional to labor input, elements of Θ, θ_{ii}, are calculated from e_i/x_i, where e_i is the the exogenously–defined total employment in industry i. Let $\mathbf{M}$ refer to an n–by–n matrix containing elements m_{ij}, which describe the number of workers required within industry i so that industry j can deliver an additional dollar's worth of output to final demand, calculated from

$$\mathbf{M} = \Theta(\mathbf{I} - \mathbf{A})^{-1},\qquad (7)$$

$\mathbf{M}^{\mathbf{T}}$, a matrix of total employment by industry directly and indirectly created by a particular pattern of final demand, is

$$\mathbf{M}^{\mathbf{T}} = \mathbf{MY},\qquad (8)$$

where $\mathbf{Y}$ is an n–by–n diagonal matrix with elements of the final demand vector, $\mathbf{y}$, on the diagonal.

Employment within n producing industries by K occupations is displayed in matrix $\mathbf{S}^{(\alpha)}$, an n–by–K matrix, with elements s_{ik}, calculated from:

$$\mathbf{S}^{(\alpha)} = \mathbf{RB},\qquad (9)$$

where $\mathbf{R}$ is an n–by–n diagonal matrix with the row sums of $\mathbf{M}^{\mathbf{T}}$ on its diagonal elements and $\mathbf{B}$ is an exogenously–defined n–by–K matrix showing the percent distribution of employment in industry i and occupation k. The occupational employment generated by each industry, shown in matrix $\mathbf{S}^{(\beta)}$, is calculated from:

$$\mathbf{S}^{(\beta)} = \mathbf{M}^{\mathbf{TT}}\mathbf{B},\qquad (10)$$

where $\mathbf{M}^{\mathbf{TT}}$ is the transpose of $\mathbf{M}^{\mathbf{T}}$. Letting $\mathbf{B}^{(\mathbf{k})}$ denote an n–by–n diagonal matrix whose elements correspond to column k of $\mathbf{B}$, n–by–n matrix $\mathbf{S}^{(\mathbf{k})}$ can be created, where:

$$\mathbf{S}^{(\mathbf{k})} = \mathbf{M}^{\mathbf{TT}}\mathbf{B}^{(\mathbf{k})}.\qquad (11)$$

There are K $\mathbf{S}^{(\mathbf{k})}$ matrices that show how many workers in a particular occupation owe their jobs to each industry's output delivered to final demand.

Literacy in Production

Let $\mathbf{c}^{(\mathbf{ik})}$ represent a vector containing the percent distribution of workers required over L literacy skill levels within industry i and occupation k. Let, matrix $\mathbf{T}$ represent the sum of $\mathbf{c}^{(\mathbf{ik})}$ vectors over I industries, resulting in an L–by–K matrix showing the showing the percent distribution of employment in literacy skill level l over occupation k. Employment within n producing industries by L literacy skill levels is displayed in matrix $\mathbf{V}^{(\alpha)}$, an n–by–L matrix, with elements v_{il}, calculated from:

$$V^{(\alpha)} = RT, \quad (12)$$

where **R** is previously defined. The requirements for literacy generated *by* each industry, shown in matrix $V^{(\beta)}$, is calculated from:

$$V^{(\beta)} = M^{TT}T. \quad (13)$$

Obviously, matrices, similar to $S^{(k)}$ matrices, can be developed to show how many workers in a particular literacy skill level owe their jobs to each industry's output delivered to final demand.

Effects of Changes in the Structure of Production and Consumption

Changes in the structure of consumption are dissected by changing the amount and distribution of total GNP reflected in revisions in **q**. Changes in **P** reflecting a new percent distribution of output from the *n* industries among *u* GNP categories are interesting from a policy perspective, but they produce no changes in employment.

To examine the effects of changes in **q**, a new vector of final demand is calculated from equation (1), which is, in turn, substituted into equation (6) to yield a new total output vector. Premultiplication of the new total output vector by **A** results in a new interindustry transaction matrix required to fill the bill of the goods and services described in the new vector of final demand. Carrying calculations through equations (9), (10), and (11) allows estimation of new total employment created within industries and occupations ($S^{(\alpha)}$), occupational employment generated by each industry ($S^{(\beta)}$), and employment generated in a particular occupation by interindustry contributions ($S^{(k)}$'s) to fulfill the changes in consumption specified. A negative element in the new interindustry transaction matrix reveals that the economy cannot fulfill the new demands for consumption of goods and services with the existing pattern of interindustry transactions shown by **A**.

Changes in the structure of production are decomposed into four relevant components:

1. Change in **A** resulting from to substitution among industrial inputs to the *j* purchasing industries;
2. Change in labor productivity of *i* producing industries, reflected in changes in Θ, resulting from capital/labor substitution or from efficiencies affected by capital/labor complementarities;
3. Change in the percent distribution of workers by occupation within industries, reflected in changes in **B**.
4. Change in the percent distribution of skills required by workers in occupations and industries, shown by changes in $c^{(ik)}$ matrices.

Changes in consumption through changes in **q** and changes in production, through changes in **A** and Θ are simulated in the body of this essay.

Application in Body of Essay

Computer Program Code

All calculations for the examples in this essay were prepared using computer code in *LEONTIEF* Version 2 (Passmore, 1990), which is a revision of an earlier version (Passmore & Wang, 1987) that did not calculate worker skill distributions or changes in employment resulting from changing production and consumption. Version 2 of *LEONTIEF* was written and tested with Version 5.18 of the *Statistical Analysis System* on an IBM Model 3090/600 computer system with 6 vector facilities operating under version 2.1 of the VM/XA operating system. A copy of the program code is available from:

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Unfortunately, resources currently are not available to assist with the installation or use of *Leontief*—Version 2 at any site other than at Penn State; even at Penn State assistance is available to students using this program code during the conduct of a course offered in the

Department of Vocational and Industrial Education, IED 574, *Strategic Planning of Education for Work.*

Correspondence of Theory With Body of Essay

Information tabulated and plotted in the body of this essay has the following correspondence to the elements, vectors, and matrices shown in the "Theory" section of this technical appendix:

In Essay	*In "Theory" Section of Appendix*
Table 2	equation 3
Table 3	equations 9 and 10
Table 4	equations 12 and 13
Figure 1	differences in results of equation 12 between current and previous economic periods

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