Technology Workers In The New Texas Economy

How Technology-Driven Changes In The Workplace Are Reshaping Choices At All Levels From Community Development To Individual Career Decisions

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Career Development Resources
Texas Workforce Commission
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Preface

This report began as an attempt to examine emerging and evolving occupations within high technology industries. What we discovered was a hodge-podge of definitions for "high technology," most of which either relied on traditional and antiquated modes for technology classification or offered loosely defined language that provided little practical basis for understanding related employment and training issues. Drawing upon the analogy of learning to walk before one can run, it became evident that we must first provide a more useful approach for discussing high technology and its practical application in terms of job generation and economic development.

This monograph lays the groundwork for future discussions of high technology from two major perspectives. The first includes definitions of what truly is meant by "high technology" or "technology intensity" from the outlook of the entrepreneur or business community. Just because a school has a computer lab in place doesn't mean that the curriculum or the faculty provide appropriate high technology instruction. The second viewpoint is an understanding of what technology means to economic development. Specifically, this monograph offers an understanding of the various roles technology plays in workforce development and as a catalyst for economic development. Without economic development, there is no need for workforce development because there will be no jobs to fill regardless of the education and training programs that are put in place.

It also became abundantly clear that issues relating to workforce development, economic development and technology application are under scrutiny from a bevy of academicians, politicians, education and workforce professionals, and private sector employers — each offering a unique viewpoint and contribution. We hope that the extensive annotated bibliography provided within this monograph and the appendix full of useful website addresses will lead other professionals to even greater works of applied research. The tact taken by this monograph is intended to guide public policy administrators in thinking through high technology issues. We also hope that workforce, education, and economic development professionals find our explanations and presentation of technology issues to be informative, pertinent and stimulating as each sector plays a role in the combined public sector response to the burgeoning world of applied technology.

Acknowledgments

The chief investigator for this project initially was Barbara Miller, Emerging Occupations Project Director for the Career Development Resources (CDR) unit of the Texas Workforce Commission. Ms. Miller resigned during the program year and relocated in Hawaii. She has been sorely missed by her colleagues at the CDR.

Work on the project was significantly expanded and completed by Marc Anderberg, Director of Applied Research with the CDR. Drafts of the report were edited by Elizabeth Dimmitt, Dr. Dan Bristow and Richard Froeschle of the CDR.

Graphics and cover design were done by Gary Tucker of the CDR.

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A special thank you goes to Dr. Neal Smatresk, Dean of Science at the University of Texas at Arlington and chairperson of the University Task Group for School-to-Careers for his insights into the role of baccalaureate, professional and graduate programs in preparing students for leading roles in the new economy and into the critically important functions of academic research and technology transfer that infuse the economy with both innovations and the teachers of tomorrow's technology workers.

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Executive Summary

No discussion of the Texas economy is complete without an assessment of the proliferation and importance of new technologies. When deployed in the workplace, new technologies create "winners" and "losers." To explain who won and who lost as the Industrial Revolution transformed agrarian economies, Joseph Schumpeter coined the term "*creative destruction*." This report uses Schumpeter's concept to explain how new digital and advanced analog technologies are creating winners and losers in the emerging knowledge-based economy:

- Which communities have the comparative economic advantages to grow and prosper? Which are likely to be left in the wake of technology change?
- Which industries will grow and flourish?
- What kinds of firms will survive the turbulence as the Texas economy is transformed?
- What kinds of skill sets will offer employment resilience and financial security in the new knowledge-based economy? What kinds of education and training will prepare workers for the demands of tomorrow's labor market?

These issues are critically important to decision-makers responsible for public policy, to planners and administrators who translate policies into action plans, to individuals who must take responsibility for their own career economic well-being and to professional intermediaries responsible for shepherding students and service-eligible customers through the workforce development system.

Unfortunately, the key term, "high technology," is bandied about carelessly in casual conversation, in the media and in policy-making forums. There is little agreement on what the term means. Everyone is certain that it is driving the new knowledge-based economy but we have hardly begun to define, measure and predict the future course of technological innovations. Most data collection systems were designed to monitor a manufacturing-based economy where change tended to be slow and incremental. Using data tied to a different economic era is akin to driving while looking in the rearview mirror. Nor are decision-makers — whether in the highest policy circles or at the individual level — likely to reach their goals and objectives if guided only by anecdotal evidence, by naive faith that technology will provide prosperity to one and all, or by an inordinate fear that technology will only degrade the environment and depersonalize relationships.

In the absence of well developed direct measures, proxy indicators can be used to help decision-makers understand the impact of technology change on economic and workforce development. We look beyond the time-series data sets that are the stock and trade of traditional labor market analysts. Predicting the direction of change requires information about new forms of comparative economic advantages, the clustering behavior of firms and supply chain integration, research and development expenditures, patent and technology transfer activities, new human resource management practices, and shifting staffing patterns.

In departing from traditional labor market analysis, we found:

- "High technology" is an attribute of specific occupations rather than a characteristic of industries or firms engaged in producing electronic goods and services. A firm that produces telecommunications equipment, for example, is likely to employ more forklift operators and warehousemen than engineers and scientists.
- All industries are being infused with technologies that transform the way work is being done. Farmers and ranchers, for example, are using global positioning technology and biotechnology to increase crop yields and livestock production.
- Within any sector of the economy, those firms with higher than industry-average investments in research and development, capital equipment and skilled workers are more likely to survive and prosper.
- There is no "one-size-fits-all" strategy communities can use to ensure economic development. Each community must exploit its comparative advantages and capitalize as best it can on the clustering tendencies of firms in the new knowledge economy.
- Infrastructure considerations are becoming more important in attracting and holding firms than is proximity to raw materials or customers. Capacity to support e-commerce is particularly important in the new knowledge economy.
- This capacity involves more than the computer hardware, signal carriers and software comprising that we commonly reference as "Information Technology" (IT). It also involves the knowledge, skills and abilities of workers who must universally deal with IT either as information producers or as information users.
- At the individual level, winners and losers in the new economy are increasingly being defined in terms of their "fluency" in technology.
- Despite all the talk about high technology, low skill jobs are not going away. Workers in those jobs simply will be paid less in real wages and will be subject to periodic bouts of unemployment and chronic financial insecurity.
    - The kinds of jobs prevalent in a community will depend in large part on the choices it makes regarding the responsiveness of labor market demands.
    - The economic well-being of individuals will depend on the choices they make among their education and training alternatives.
    - New kinds of data on the relationship between technology change and occupational employment hold the key to informed choice in policy making and individual career choice.
- To prepare for employment in high technology occupations, students and adult learners need a solid foundation in mathematics and science. They also must understand the importance of lifelong learning to keep their knowledge, skills and abilities up to date.

Summary of Recommendations

The original scope of this report did not include policy recommendations. After extensive research for this report was completed, the authors felt compelled to highlight potential policy considerations to address the dynamics associated with technology and its impact on the new Texas economy. The following recommendations flow from this wide body of research and are intended to stimulate discussion among policy-makers, public sector representatives, program administrators and private citizens alike.

1. Revisit economic development strategies to maximize the local labor market's comparative advantages that are most relevant in a new knowledge-based economy.

> Validate the structural changes in various sectors of the economy locally. Identify your area's unique comparative advantages to fine-tune a targeted economic development strategy.
>
> Don't overlook the potential of less glamorous and relatively low tech industries poised for
> take-off and favored by the area's comparative advantages.
>
> Fit local economic development initiatives into a broader regional master plan. The best strategy for rural areas is to build linkages to and piggyback on the economic development efforts of neighboring urban centers.
>
> "Footloose" industries should be considered fair game for any community's economic development efforts.

2. Recognize the utility of indirect strategies for economic development.

> In addition to addressing the needs of specific firms, improve the community infrastructure to build future capacity for economic expansion.
>
> Provide technical assistance to help all local businesses get involved in existing technology transfer networks.
>
> Consider underwriting business incubation activities.
>
> Collaborate with other stakeholders to remove barriers and speed up the entire process of technology transfer.

3. In building workforce development partnerships, aggressively recruit representatives of local industries that are moving most rapidly up the scales of technology- and knowledge-intensity.

> When forming workforce development partnerships, don't overlook the smaller and younger firms in the community — especially those whose organizational structure are relatively flat. They are the "most likely suspects" to be moving up the scales of knowledge- and technology-intensity (regardless of industry sector). Their needs are more likely to push curriculum revision to the cutting edge.
>
> Use resources provided by the Career Development Resources (CDR) unit of the Texas Workforce Commission (TWC) to identify prospective partners and to facilitate contact with their chief executives or human resource officers.

4. All occupations (both in the information technology related industries and in all other sectors of the economy) should be monitored constantly. We need to anticipate changes in the technology-intensity of occupations and the implications such changes will have in terms of the knowledge, skills and abilities required for occupational employment. Constant monitoring is the only way to give all stakeholders the early warning they need to plan strategically for education, training and workforce development.

> Assuming that current labor market and occupational analysis should be at the core of workforce program planning and educational curriculum development, several funded positions should be identified and assigned the task of monitoring the technology-intensity of occupational employment in Texas. Their findings should be integrated with occupational employment demand forecasts, new occupational taxonomies, detailed information on the knowledge, skills and abilities (KSAs) required in each occupation and supply side information on related education and training programs.

5. Concerted efforts must be made to connect occupational and labor market dynamics to curriculum development, career counseling and workforce development.

> Effort must be made to go beyond gathering and synthesizing information about employer-specified KSAs for technology-intensive occupations. Strategies must be devised (along with possible rule changes) to ensure that these data are used effectively in strategic planning and career guidance.
>
> > KSA statements derived from occupational employment analysis ought to constitute the learning objectives of related occupationally-specific education and training.
> >
> > - The curriculum for occupationally-specific education and training programs ought to be built around employer-validated KSA requirements.
> > - Program completion ought to be based on "*authentic assessment*." Assessment should be "*criterion-referenced*" rather than "*norm-referenced*." Completion should be contingent on demonstrated competency in all technologies integral to job-related performance.
> > - A credential on its face should make it easy for prospective employers to determine what the student (as a job applicant) knows and can do.
> > - Expanded transcripts and portfolios should be structured around employer-validated KSAs for related occupations.
> > - Applications for program approval and funding ought to specify how KSA requirements will be addressed by the curriculum, assessment at program exit and in the credentialing process.
> >
> > KSA statements should be the focal point of other kinds of services delivered through or brokered by the one-stop workforce centers.
> >
> > - Each on-the-job training (OJT) agreement should specify the KSA and proficiency outcomes the participant is to achieve.

- Case managers should consult with the workforce center's labor market specialist about the anticipated employment opportunities and earnings potential of an occupation before arranging an OJT with the employer and trainee.
- Firm-specific and skills gap training ought to be targeted to specific high demand, technology-intensive occupations rather than to broad industry clusters.
- Firm-specific and skills gap training contracts ought to specify the courses to be taught in standardized terms in the Workforce Education Course Manual or Classification of Instructional Programs (CIP) taxonomy.
    - Any Requests for Proposal (RFPs) to secure firm-specific or skills gap training grants should require proposers to explain how technology change has impacted occupational KSAs and how those changes will be addressed.
    - Contracts for firm-specific and skills gap training should stipulate deliverables in terms of proficiency levels and competencies that program completers are to demonstrate in relevant technologies.
    - Student/participant outcomes for firm-specific or skills gap training should be recorded and certified in terms of KSA competencies demonstrated and proficiency levels achieved.
    - For maximum return on investment of public funds, firm-specific training should be targeted to companies that are: above average in technology intensity; in industries which drive local economic development; paying their workers at or above the prevailing industry wage levels; and growing at a faster rate than other local firms.
    - For maximum return on investment of public funds, firm-specific training should be targeted to occupations at least where the "job duties rely on some advanced technology" according to the CDR's technology-intensity metric.
    - KSA requirements should be the focal point of case management in workforce development and career counseling in public education.
    - Each Individual Training Account (ITA) voucher issued under WIA should specify the customer's learning objectives in terms of KSAs for occupations on the local workforce investment board's target list.

6. An entire unit should be added to the middle school career investigation curriculum to address the essential elements of technology change and its impact on the students' future employment and earnings. The connections between technology change and requisite KSAs for occupational employment in high wage, technology-driven fields should be reinforced throughout the remainder

of coherently sequenced courses in every career cluster.

- The graduation plan for each Career and Technology Education student, ought to specify:

    what KSAs and proficiencies the student is to demonstrate;

    how those KSAs relate to local occupational employment demand and the student's earnings potential;

    how any anticipated changes in relevant technologies are likely to affect occupational KSA requirements, postsecondary learning objectives and future employment prospects in the student's chosen career field;

    how those KSAs relate to subsequent pursuit of additional education and training — particularly for programs specifically articulated with course offerings at nearby postsecondary institutions; and

    how the student's KSAs and proficiencies will be communicated to prospective employers and postsecondary institutions.

- More attention should be given to advanced career investigation while students are pursuing concrete majors at the postsecondary level.

- Upgrade the career guidance role in the Student Services division of postsecondary institutions.

- Include all publicly funded and volunteer private institutions' baccalaureate and post-baccalaureate programs in Texas's Automated Student and Adult Learner Follow-Up System.

- Results from follow-up on former baccalaureate and post-baccalaureate students should be included in Texas's automated consumer information system, DECIDE, to provide subsequent cohorts with the data they need to make informed career choices.

- Best practices from the School-to-Careers transition model currently being implemented in K-12 and technical education at two-year postsecondary institutions should be used to guide similar efforts in traditionally academic programs offered by two-year institutions, in baccalaureate programs and in post-baccalaureate programs.

7. Revise rules and procedures to accelerate the delivery of an updated curriculum for education and training targeted to technology-driven, high growth occupations.

- Re-examine the way new programs at public postsecondary institutions are funded.

    Establish a contingency fund for program start-up at public postsecondary institutions and make it easier for public postsecondary institutions to enter into collaborative arrangements with the private sector.

- Provide education and training on demand.

- Allow for venue-neutral, modality-neutral assessment.

8. In the absence of occupationally-specific programs, students who aspire to careers in emerging, high tech fields should be advised to acquire solid foundation skills and knowledge in mathematics, science, engineering and closely related technical fields.

9. Students and adult learners also must understand that rapid change probably will render obsolete the knowledge, skills and abilities they are currently acquiring. They must understand that accepting responsibility for their own future economic well being will require them to engage in lifelong learning.

Companion Report Forthcoming
from
Career Development Resources

This report deals primarily with the impact of technology change on the demand for highly skilled workers in the new Texas economy. In this report, we allude to data that indicate a shortage of appropriately skilled workers. However, recommendations in this report focus on ways to keep the **contents** of education, training, workforce development and economic development programs responsive to employer demands and how to make students and adult learners **aware of career opportunities** in high technology occupations offering high wages and long-term employment resilience.

A companion report, *The Digital Divide in the New Texas Economy*, is forthcoming from Career Development Resources. It will provide a more detailed examination of the domestic supply of appropriately skilled workers for the new Texas economy. In particular, it will look more closely at the under-representation of females, minorities, disabled persons and older workers in high technology occupations. Recommendations in the forthcoming report will focus on eliminating barriers, engaging the interest of under-represented groups and attracting more of them to high technology education and training programs and providing them the support they need to persist to program completion and labor market entry.

Technology Workers in the New Texas Economy

I. Introduction

In 1911, Joseph Schumpeter challenged classical economics by postulating his *Theory of Economic Dynamics*. Schumpeter claimed that "dynamic disequilibrium" rather than equilibrium and optimization is the hallmark of a healthy economy. To put it in simpler terms, **a stable economy is apt to stagnate while a dynamic, ever innovating economy is likely to grow and prosper.** One of the unfortunate but necessary side effects of growth in a healthy economy is the demise of outmoded means of production and the disappearance of both firms and jobs tied to old ways of doing business. Schumpeter called this dynamic process "creative destruction." Peter Drucker and other contemporary economists have revived Schumpeter's theory to explain the dynamics of today's knowledge economy.

P. Drucker, *Innovation and Entrepreneurship: Practice and Principles*. (New York City, NY: Harper and Row, 1985)

This study examines how creative destruction shapes the knowledge economy. We look at how the new technology at the heart of the knowledge economy accounts for the growth of some sectors, the prosperity of some firms, and high demand at high wages in some occupations while diminishing — even destroying — the prospects of others. In modern terms, creative destruction has created two vastly different labor markets separated by a "digital divide."

The process of creative destruction and the resultant digital divide are at the very heart of the issues confronting planners and program administrators who must formulate workforce and economic development policies. Which industries are the best prospects for driving local economic development? Which industries employ lots of workers but pay relatively low wages? Which occupations exhibit increased employment demand at high wages? How does technology separate the two distinct labor markets? What, if anything, do high paying jobs have in common? What are the education and training requirements for jobs on the prosperous side of the digital divide? Which demographic groups and communities are likely to be left behind as others prosper?

Creative Destruction in Texas's Knowledge Economy

Increased business and consumer demands for information technology fueled phenomenal economic growth in Texas during the 1990's. Businesses needed micro-computers, networks, application software, Internet connectivity, communications and electronic equipment. Consumers also wanted computers and connectivity for home use. New jobs — most often at wages above the statewide average — were and still are being created as a result of increased demand. Someone has to design new products, fabricate micro-chips and other components, assemble the devices, package and ship finished goods, market and install them, integrate them with legacy systems, support them, maintain them, operate them and install periodic upgrades. These sorts of activities constitute the positive part of the "*creative*" process — dramatic changes that catch the public's attention.

Occupations associated with advanced technologies pull the Texas economy along in terms of the **rate** of new job creation. This growth in leading-edge technology fields has a ripple effect. Job growth in more mundane fields actually was much larger in **absolute terms.** High-wage earners demand personal services and consumer goods. They eat out more often, for example. They tend to have more disposable income to spend on lawn care, clothing, entertainment, travel and accommodations, household gadgets, etc. Thus, Personal Services, Hospitality and the Retail Trades accounted for most of the total increase in job openings in Texas during the last decade. Most occupations in these sectors already existed in large numbers. Therefore, their **absolute** employment demand growth did not represent a particularly dramatic **rate** of increase. This, too, is part of the creative side of the change process — indeed, the lion's share of it. Unfortunately, many of the jobs in the Service Sectors and Retail Trades are relatively low-skill and provide low pay and they don't involve the kind of whiz-bang technology that captures the public's fancy.

> The tremendous growth rate in demand for workers in high-tech jobs constitutes only the tip of the labor market iceberg — the most visible part — that resulted from creative destruction. The less visible but more mas-sive part consists of the demand growth in absolute terms for workers in low-skill jobs that pay far less than the new high-tech jobs.

Technological innovations that created whole new industries and new job categories also contributed to declining employment demand in older, more traditional industries and occupational fields. Monotonous, repetitive, micro-managed jobs in manufacturing are especially susceptible to being eliminated by automation. But declining employment demand is not limited to the manufacturing sector. Jobs across all sectors of the economy are eliminated, for example, when businesses install office automation suites. Such "desktop solutions" enable managers, supervisors and professionals to do their own typing, filing, data or inventory tracking, and calculating. That makes many kinds of clerical positions superfluous. These examples illustrate the "*destructive*" side of changing technology. While destructive forces of change have a negative impact on the economy, bad news receives less media attention and fanfare.

Somewhere in the middle of all this churning are turnover statistics. The tools of the trade change so dramatically that incumbent workers in some occupations can no longer perform their jobs adequately. Existing job categories whose duties and tasks or tools of the trade change dramatically are called "*significantly evolving occupations*." Although workers' jobs aren't reclassified, the knowledge, skills and abilities (KSAs) required to be productive in them are altered by new technology. In some occupational categories, KSA requirements change so extensively that current education and training practices no longer prepare workers adequately for these jobs. Unless they obtain additional, leading-edge education and training, incumbent workers in significantly evolving occupations will be replaced by job-seekers with more current KSAs.

Employment Resilience

These days, labor market economists speak in terms of "*employment resiliency*" rather than about "*job security*" or "*career stability*." As the pace of technology change accelerates, it is increasingly unlikely that an individual will remain in the same job with the same firm for his or her entire work-life. Indeed, entire occupations — even some high-demand, high paying high-tech jobs of today — may be wiped out by the creative destruction process. *Resiliency* is the best-to-be-hoped-for characteristic of employment in the future. *Employment resiliency* refers to the likelihood that: 1) an individual will move between jobs with few episodes of unemployment; 2) any bouts of unemployment experienced will be relatively short; and 3) full wage replacement or earnings gains will be realized in each successive career move.

The media pay less attention to evolving occupations when they lie outside headline capturing sectors of the economy like computer manufacturing and telecommunications. Besides, turnover in evolving occupations has little effect on **net** change in employment demand. Nonetheless, turnover does have significant consequences. While technology-savvy workers command high wages in emerging and evolving occupations, their prosperity is offset by the economic insecurity of job-seekers who lack leading-edge skills. In a knowledge-based economy, earning potential is tied to attaining at least some postsecondary education and training. Employment resiliency is now tied more directly to continuous skills acquisition. Workers displaced by technology endure economic hardships. First-time job-seekers who enter the labor market without high skills will face good employment prospects but in low-wage jobs.

Prior to the 1990's, workers with no more than a high school diploma could earn high wages in manufacturing jobs despite the relatively low skills required. Collective bargaining and accrued seniority bolstered wages. However, high-wage/low-skill jobs were the most likely to be destroyed in the transition from a manufacturing-based economy to a knowledge-based one. Workers dislocated by the destructive side of technology may have possessed the brawn, endurance and pliability to succeed in jobs tied to mass production; few, however, have portable higher order skills that qualify them for new high-wage/high-tech occupations. Many dislocated assembly line and production workers — if they find new work at all — wind up in the Service Sectors and Retail Trades. Often they suffer dramatic earnings decreases. Job-seekers just coming of working age who lack advanced technology training also find themselves milling around in the low-wage tide pools of the knowledge economy. So do older, unskilled persons (e.g., "displaced homemakers" or welfare-to-work program participants) as they enter the labor market for the first time.

Creative destruction results in structural changes in employment and earnings patterns. Economic self-sufficiency and long-term financial security are affected directly by the personal career decisions of individuals. Individual career options are affected in turn by policy-makers' efforts to spawn job creation through economic development. Individual career options also are affected by opportunity costs incurred in pursuing education and by the availability of appropriate training options. Thus, individual career choice is intertwined inextricably with: the strategic plans

Employment Demand Statistics Often Mask a Whole Lot of "Churning" Below The Surface

Ms. Able had been the chief accountant for Acme Widget Manufacturing, Ltd. since 1971. She was trained to make journal entries manually. She used a ten-key calculator to check account totals and ledger balances. When Acme automated its bookkeeping, Ms. Able was replaced by a newly minted MBA. The new-hire had taken course work in e-Commerce. The office where she did a summer-long internship uses the same accounting software now installed at Acme. By mastering automation tools, the new-hire is 50% more productive than Ms. Able had been. But because the new MBA was fresh on the job market, she was willing to work for 25% less than Ms. Able was paid. The new MBA's official job title is still "*accountant.*"

For ten years, Ms. Carter, 42, was a tool-and-die maker with Block and Tackle, Inc. The firm installed a numeric process control system. That equipment drives roboticized production straight from electronic blueprints and specifications. Block and Tackle, Inc. replaced Ms. Carter with a numeric process control technician. Both Ms. Carter and her replacement officially were classified as "*precision tool operators*." The numeric process control technician earns more than Ms. Carter did. The earning increase in the job at Block and Tackle is about the same as the earnings decrease for the accountant's job at Acme.

Mr. Baker, 46, was a draftsman with the construction firm of Molson, Foster, Miller and Killian. Since 1975 he had used a t-square and other conventional tools to design bridges under the supervision of Red Killian, the chief engineer. Then the Department of Transportation adopted a rule requiring all firms bidding on state-funded highway projects to attach electronic copies of all designs to their proposals as exhibits. Killian and his partners converted to an AutoCAD system. Mr. Baker was replaced by a recent associate degree-earner. Although the new-hire had no prior work experience, he proved himself to be a whiz at AutoCad. By demonstrating that he could be productive, the whiz could command the same pay as did Mr. Baker. The new hire's job title is still "*drafter*."

In all three scenarios, new technology impacted traditional occupations — even if the job titles didn't change — in sectors of the economy that aren't commonly considered high tech. We call these *"significantly evolving occupations*." In all three cases, technology implementation affected worker skill requirements and changed the wage hierarchy. For the economy as a whole, the **net effect** of these combined scenarios is **no employment growth and zero increase in the total wages paid**.

Does this mean that these actions were insignificant? Certainly not! Relatively stable demand and wages in the evolving occupations can mask the churning as incumbent workers with outmoded skills are replaced by new hires who have mastered the more advanced tools of the trade. What are the ramifications of theses innocuous appearing statistics for Able, Baker and Carter? All three are looking for work. Their skills, however, are obsolete. Unless they get additional education and training, they are unlikely to find work in their previous career fields. If they do find work, it probably will not be at full wage replacement.

The point is that the divide between the high skill/high wage labor markets and the low wage one is not impenetrable. Some new job-seekers will master digital technologies. They cross the divide into high paying jobs. Meanwhile, some incumbent workers previously considered highly skilled may move in the opposite direction. When tools of a trade are rendered obsolete by digital technologies, workers who used them may fall below the divide — perhaps permanently. Their futures may be characterized by low-wage employment, episodic unemployment, occasional welfare dependency and chronic financial insecurity.

of community leaders and economic developers; prevailing employment practices; the quality of advice they receive from counselors, case managers, family and friends; and the responsiveness of the curriculum.

Stakeholders at all levels must share a common understanding of the economic environment. If they are to optimize their economic activities in the labor market of the future, all stakeholders need to know how structural change has affected: 1) the rise and fall of specific industries statewide; 2) the mix of industries within substate labor markets; 3) the fortunes of firms within each sector; 4) occupational employment demand within industrial staffing patterns; and 5) the impact of technology change on firms' policies and practices regarding retention, promotion and compensation of incumbent workers within each occupation.

By examining the economic shake out of communities, industries, firms, occupations and individual workers, analysts have found a common thread. Namely, all the economic upheaval has resulted in two separate and distinct labor markets. One of the labor markets offers relatively high-paying jobs with sound prospects for employment resiliency and career advancement. The other labor market features: low wages; a greater prevalence of part-time and/or temporary employment; higher turnover rates and a greater likelihood of seasonal or cyclical lay-offs; above average probabilities of being displaced by automation; fewer internal (firm-specific) career ladders or external (within-industry) pathways to better paying jobs; and an almost total lack of formal learning opportunities to acquire new skills on the job that might help incumbent workers keep pace with changes in the workplace.

These very divergent prospects for labor are a defining characteristic of a knowledge-based economy. The two distinct labor markets are separated by a "*digital divide*." Digital technologies are integral to the knowledge-based economy. Individuals who have access to, understand and have mastered at least one advanced digital technology (LAN administration, for example) are more likely to obtain higher paying jobs and enjoy employment resilience. Conversely, those who have limited access or who are not technology savvy most likely will fall on the low-wage side of the digital divide. Their prospects for economic security and financial independence are slim.

> Even the U.S. Department of Commerce (in its *Falling Through the Net* series) attempts to define the digital divide in terms of access to the Internet through computers at home or at work. Mere access, however, is not the same as "*proficient*." A more useful approach differentiates the relatively passive users from those who are "*fluent*" in technology. See, for example, John Galvin, *Education's Response to the Information Technology Worker Shortage;* Joyce Malyn-Smith, *IT Pathway Pipeline Model*; and National Research Council, *Being Fluent with Information Technology.*

The "*digital divide*" is defined in our pop culture as the separation between those who have access to the Internet and those who do not. That dichotomous definition (the "*haves*" versus the "*have-nots*") is far too superficial. When forecasting the impact of technology on employment, we must keep in mind that the Internet is not the only digital technology with a capacity to create new occupations, destroy existing ones and significantly transform others. Secondly, one can have access to the Internet for trivial (non-economic) pursuits (e.g., playing games or sending personal e-mail) that don't require mastery of the underlying technology. Relatively passive consumption of Internet-based services has little bearing on an individual's employment and earnings prospects. An individual's **mastery** and **productive economic uses** of one or more digital technologies are critical distinctions when trying to predict how he or she will fare in the dual labor market.

> Lots of people have Stairmasters™ or NordicTracks™ in their homes but that doesn't mean they are fit. Lots of people have Internet connections in their offices or homes but that doesn't mean they are fluent in information technology.

The most pertinent question for individual decision-makers and policy-makers alike is: Where are the good jobs of the future? (While personal considerations go into an individual's definition of a "*good job*," the term is used herein to refer to positions that offer high wages and reasonable prospects for employment resiliency.) Knowing where to look is the first step in putting people to work in high paying jobs. To locate the good jobs of the future, one must understand the sorting out that has occurred among communities, among business and industry sectors, among firms within each sector, among occupations within each broad industry's staffing patterns, and among individual workers in particular occupations.

II. Knowledge-Intensity at the Industry Level

Indicators of knowledge- or technology-intensity provide clues that help unravel changes at the industry level and to predict economic growth for specific communities or labor markets based on their current industry mix and their comparative advantages.

Novelty, complexity and sophistication aren't necessarily the most critical factors in determining the impact of new technologies on employment demand.

- Some brilliant scientific concepts and elegantly executed experiments never make it beyond the bench science phase (i.e., out of the laboratory, off the drawing board or out of the tinkerer's garage) because their practical uses have not been demonstrated.
- Sometimes, useful spin-offs from bench science don't penetrate the workplace or don't make their way into the retail consumer market because their inventors fail to see the commercial potential. Even the most brilliant inventor may lack sufficient entrepreneurial spirit to secure vitally important venture capital.

Digital Technologies: They're Everywhere!

When people talk about "*high technology*," they most often are referring to computer hardware, software and telecommunications equipment (collectively known as *"information technologies*"). Companies like IBM, Compaq, Dell, Intel, MicroSoft, Oracle, Cisco and Motorola quickly come to mind. Note, however, that the key term used herein, "*digital technologies*," is not limited to personal computers, software and communications equipment and services. We construe the term broadly to include operating systems, networks, application software, software development tools and utilities, e-commerce platforms and web-site construction aides, peripherals and communications devices as well as microcomputers and personal workstations. We also use the term to encompass processes and production methods driven by the results of scientific research that are stored on and accessed by skilled professionals through digital equipment.

Digital technologies currently are deployed in virtually every sector of the economy. Penetration of digital devices or the reliance on digitally stored and accessed information, however, is more pervasive and obtrusive in some sectors than in others.

For example, health care, strictly speaking, doesn't fall into the field of "*information technology*." Nonetheless, digital technologies are at the very heart of major changes in health care delivery. Digitally-driven imaging devices (MRI and CATScan, for example) are used in diagnostics. Digitally-calibrated devices are used when treating patients. Expert systems and real-time asynchronous communications enable specialists in urban locations to: guide nurse practitioners in delivering health care to patients in remote areas; share e-charts to get second opinions from other specialists at a distance; or transmit e-prescriptions accurately and promptly to a patient's closest pharmacy. On-line resources (e.g., a searchable electronic version of the *Physicians' Desk Reference*) and massive databases (such as the ones associated with the Human Genome Project) will help doctors tailor remedies to an individual's particular genetic make-up. Electronically scanned lookup tables can alert doctors to contraindications and negative synergistic effects of inappropriate drug combinations for patients with multiple ailments.

Similarly, the general public seldom associates agriculture with advanced technologies. Nonetheless, agriculture is being transformed radically. Global positioning systems (GPS) are being used to ensure more efficient use of fertilizers, herbicides, insecticides and irrigation. Data gathered by Earth-surface scanning satellites are used to calculate appropriate application rates (pinpointed down to $^{1}/_{10}{}^{th}$ of an acre) according to prior crop yields and current soil conditions. Farmers turn to on-line resources to investigate the pros and cons of using genetically-engineered seeds to im-prove crop production. Ranchers tap web-sites (like the one hosted by the National Animal Disease Center) to improve the health of their livestock or to track the hoof-and-mouth disease epidemic in Europe or anthrax outbreaks in Uvalde. They rely on computerized databases to track their use of chemicals and feed additives to ensure compliance with agricultural and environmental regulations. Farmers track commodity market activities electronically in order to sell their products and options on their future production for maximum profitability.

Advanced Analog Technology

Digital devices like computers and telecommunications equipment get most of the press coverage. Meanwhile, significant advances are being made in analog technology. “Analog technology” refers to devices or products developed by humans to mimic natural or biological functions. Analogies between man-made devices and biological functions, for example, are easy to see in the movement of robotic arms that “grasp” soldering irons to weld automotive components or “grip” a hammer to drive rivets. Parallels also are easy to see in the more familiar modern medical miracles. Artificial heart values can be built to replace their biological counterparts that don’t function properly. Artificial knees and hips are used to replace biological ones that have worn out or to reconstruct ones that have been damaged.

In other fields of medicine, it is more difficult for most of us to understand that analog technology is at work because, as laypersons, we don’t understand how the complex biological counterpart functions. If we don’t understand the original, how can we fathom a man-made device that can replace it or outperform it? It is even harder to comprehend analog technology if the imitated biological function occurs out of sight or on such a small scale or at such high speeds that it’s not noticed by the naked, untrained eye. In a sense, pharmaceuticals fall into the realm of “analog technology.” While we don’t think of them as a “*devices*,” drugs are man-made compounds or synthetics that imitate or improve the way our immune, respiratory, digestive or neurological systems function. With advances in our understanding of DNA, pharmaco-genomics soon will allow humans to replicate and alter the way organic cells form, function and “*learn*” to function better.

Nano-technology (miniaturization) primarily involves analog devices. Microscopic mirrors (small enough for 250 to be placed on a silicon wafer the size of a pinhead) can be used to route the direction of optical signals. Nano-technology is being developed to use compact disk-like devices for mixing small quantities of chemicals. Such man-made devices emulate large scale switches or chemical laboratories that once were operated by hand — and they function with greater precision and speed.

> For explanations of advanced technologies in lay terms, see issues of *Technology Review* magazine from the Massachusetts Institute of Technology available on line at http://www.techreview.com and issues of the *Technology Quarterly* published by the editors of *Science* magazine available at http://www.science/tq/index.cfm. For a digest of international technology developments, see the science section of the *Economist* magazine from England available on line at http://www.economist.com/science/index.cfm.

In fact, most emerging technologies involve a mixture of digital and analog devices. The Department of Defense, for example, has developed an advanced operating room for the battlefield. Rather than lose precious time evacuating the wounded to a hospital far behind the lines, medics will take them to an armored vehicle at the battlefront. The vehicle will contain robotic devices and digital communications equipment. Cameras and diagnostic equipment will bounce a digital image and digitized vital sign information of a satellite to a surgeon in a remote field hospital. The surgeon, viewing the images on screen in real time, will maneuver joystick-like devices at the hospital workstation. Joystick movements are converted to a digital signal that is bounced off the satellite back to the operating room to control robotic arms and fingers to perform precise surgery on the wounded.

> See Scientific American Frontiers Series, *Affairs of the Heart*, premier broadcast on Public Broadcast System stations in January 23, 2001; broadcast throughout spring 2001 in Austin on KRLU.

Throughout this report, wherever the term “*digital technology*” is used, we usually are using that as a shorthand to mean “*digital and advanced analog technologies*.”

- Some demonstrably useful technologies fail to make a significant impact because the industries that would benefit most from them are resistant to change.
- Some technologies fail to make their mark because other technologies devised for comparable purposes hit the ground at the same time with stronger financial backing and/or better marketing strategies.
- Some new technologies take off in the consumer market but all of the assembly jobs and most of the distribution jobs that they create end up outside the United States. It is quite possible for a new technology to be successful and still have minimal domestic and local employment impact.

Thus, factors such as utility, potential-user receptivity, access to venture capital, sound marketing efforts and timing often are more crucial to technology transfer than novelty, complexity or sophistication. If ideas don't make it from the laboratory and drawing board to the workplace or into the consumers' shopping baskets then they don't influence employment demand.

> See Gompers and Lerner, *The Venture Capital Cycle* (Cambridge, MA: MIT Press, 1999); R. Henderson, *Under-Investment and Incompetence as Responses to Innovation* Rand Journal of Economics vol. 24 (1995); J. Reinganum, *The Timing of Innovation: Research, Development and Diffusion* in Schmalensee and Willig (ed.) *Handbook of Industrial Organization* (New York City, NY: North-Holland, 1989); E. Rogers, *Diffusion of Innovation* (New York City, NY: The Free Press, 1995); and D. Osborne, *Laboratories of Democracy* (Boston, MA: Harvard Business School Press, 1990).

Employment demand growth, *per se*, is not a reliable indicator of which industries are most technology-driven or knowledge-intensive. When a new technology is adopted widely in a particular economic sector, net employment demand in that business or industry cluster may decline initially. Large numbers of incumbent workers may be replaced with automated processes operated and maintained by a smaller number of differently-skilled workers. Productivity-enhancing technologies eventually pay for themselves. As profits increase, some portion can be plowed back into business expansion. At that point, employment demand in the industry tends to rebound.

The following indicators may be more useful than industrial employment demand in identifying technology-driven industries:

1. Technology-driven industries tend to be more capital intensive. That is, their ratio of capital (K) to labor costs (L) for the production of goods and services is high. In this ratio, "capital" is defined as investment in fixed assets and inventories. "Labor costs" are defined as gross annual payroll.

   > See Gera and Masse, *Employment Performance in the Knowledge-Based Economy* Ottawa, Canada: Industrie Canada, 1996); also see Haltiwanger and Jarmin, *Measuring the Digital Economy* (Washington, DC: Center for Economic Studies/US Bureau of the Census, 2000).

   The position of one industry relative to others on a scale of technology penetration is not static. Changes in prevailing technology don't necessarily occur for any given industry at a smooth and steady pace. Whole sectors are repositioned in fits and starts. An entire industry can move up the scale quickly. Then it may be caught and passed by other industries during a hiatus in innovation and implementation. Later, the industry may undergo another round of technology change that leapfrogs it once again over other industries.

Look beyond the static K:L ratio for an industry at a single point in time. Assess changes in an industry's K:L ratio over an extended period. Also look at the rate of change in a particular industry's K:L ratio relative to what is happening in other industries operating side by side in the same labor market.

Repositioning of entire industries can occur all up and down the scale of technology penetration. Even if an industry's K:L ratio is low compared to other industries, the nature of work therein may be undergoing profound transformations if the K:L ratio is increasing at a faster rate than it is in other industries. This is an important point for economic developers ato keep in mind.

> All communities can't expect to grow their economies by emulating the model used in Austin, Texas to attract microchip and related electronic component manufacturing. An economic developer must identify the community's best prospects — not belatedly coveting industries located elsewhere which have nearly run the table of technological innovation. Determine which local industries are poised at a critical take-off point.
>
> Even if a local industry is considered "low tech" by conventional wisdom, the first sign of an upswing in its K:L ratio may alert economic developers to the industry's growth potential. Stimulating even modest growth in a local industry may be of little consequence on a statewide scale, but it might help the community hold on to its best and brightest youths.

2. Technology-intensive industries are characterized by higher than average investments in research and development (R&D) as a percentage of gross sales. R&D expenditures in industries poised for take-off tend to increase at faster rate than in other economic sectors.

   2.1. Technology-intensive industries tend to have a high ratio of patents and copyrights to workers. A statewide chain of cafeterias employing thousands of food service workers, for example, is apt to hold no patents. By contrast, a three-person firm engaged in scientific and engineering consulting might hold scores of patents. A software developer working as a sole proprietor might have a more than a score of copyrights. (See Gera and Masse, *Ibid*.)

   2.2. We would expect technology-driven companies might derive a high percentage of their revenues from patent licensing and royalties. However, many firms do not break out such items even in the financial statements to their investors.

   > See F. Gu and B. Lev, *Markets in Intangibles: Patent Licensing* at http://www.stern.nyu.edu/blev/ (May 2000).

3. A technology-intensive industry tends to have a relatively high concentration of professional, managerial and technical workers (white collar) relative to the number of production workers (blue collar) in its staffing pattern.

   > See Gera and Masse, *Ibid.*; N. Beck, *Shifting Gears: Thriving in the New Economy* (Toronto, Canada: Harper-Collins, 1992); and G. Rose, *Employment Growth in High-Tech and Knowledge Industries* (Ottawa, Canada: Department of Finance,

Economic Analysis and Forecasting, 1992).

3.1. Technology-intensive industries have a high ratio of workers with a postsecondary credential to workers with a high school diploma or less.

See Gera and Masse, *op. cit*. and Autor *et. al. Computing Inequality: Have Computers Changed the Labor Market?* (Washington, DC: National Bureau of Economic Research, 1997).

3.2. Technology-intensive industries tend to have a high ratio of workers with mathematics, science and engineering degrees to workers with other kinds of education and training.

See Gera and Masse, *op. cit.* and the Task Force on Developing the Technology Workforce, *Expanding the Technology Workforce* (Austin, TX: Texas Higher Education Coordinating Board, 2000).

For the same reasons outlined previously, it also is important to look at the **rates** at which the ratio of professional/managerial/technical workers to production workers, the average educational attainment among workers, and the ratio of workers with math, science and engineering degrees to other workers in the industry are increasing. Small upward changes in these factors can signal economic developers that even a relatively low-technology industry in the community is poised for take-off.

4. There tends to be a high degree of product substitution for the goods and services provided by technology-intensive industries. The term "*product substitution*" is used by Canadian (Gera and Masse) and European researchers (the Organisation for Economic Co-operation and Development, for example) to describe industries where customers have a wide range of choice. In industries in a holding pattern, a number of firms compete for customers by offering virtually identical products. They may compete on price, delivery or reputation. In technology-intensive industries, competition is driven more by the range of alternative products and services where differences in features and benefits are more than cosmetic. In these industries, innovation and speed-to-market can provide a competitive edge.

4.1. Technology-driven industries tend to offer products whose "*half-life*" is relatively short. That is, the durability of a product's construction makes its "*serviceable life*" longer than the customer's perception of its performance adequacy.

Illustrations of Key Terms

Product Substitution

Customers looking for printers to produce hard copy outputs are offered a wide variety of technologies. Thermal printers require heat-sensitive paper while laser printers can use plain paper. Dot-matrix printers come in both ribbon and ink-jet varieties. Within each of these technologies (except thermal) the customer can choose between devices that produce images in black, white and shades of gray or in color. Among color output devices, the palette range varies widely. For all the above, the customer also can choose on the basis of speed, resolution or paper-handling and form-feeding attachments. Now competitors have introduced multipurpose output devices. Some double as a laser printer and photocopier. More recently, "I/O Stations" have been introduced that serve as a combination printer, photocopier, facsimile, scanner, digital image editing device and router to provide multiple workstations access to a shared network modem. Thus, product substitution implies that customers have the ability to select among similar products that have substantially different features and benefits. The differences are not merely cosmetic.

Product "*Half-Life*"

The concept of a "*half-life*" comes from the study of radioactivity among heavy elements in the periodic table. Radiation emitted by a piece of uranium decreases over time. Centuries from now, a chunk of uranium will still exist physically but the amount of energy released for use in generating electricity will be diminished. Consumer products can follow the same curve. For example, slow low-resolution dot-matrix ribbon printers with tractor attachments for form-feeding and paper-handling were well constructed. They could keep printing almost indefinitely without repairs. Nonetheless, many still-functioning dot-matrix printers were abandoned when laser printing technology enticed customers to redefine their needs in terms of faster output and higher resolution.

Time-Sensitive Competition

Hewlett Packard (HP) currently estimates that 90 percent of the revenues generated by each new printer model come in the first two years after it hits the market. More than 75 percent of all HP's revenues come from products less than four years old. The time frame for maximum revenue generation is ever shortening. Therefore, to hold on to its market share, HP tries to stay ahead of its competitors by being the first to offer consumers newer models with significantly improved features and benefits. The new models make HP's own predecessor models obsolete.

Vertical Integration

The following supply-chain scenario illustrates the concept of vertical integration. A nationwide retail electronics firm is an authorized dealer for a particular brand of computers. Each outlet in the retail chain has direct access to the computer manufacturer's inventory control system. The retail store's clerks can place orders directly with the factory or check the status of items on back order. The computer manufacturer, in turn, has direct access to the inventory control system of the firm that manufactures its CD ROM drives. The CD ROM supplier has direct access to the inventory control system of the firm that supplies microchips used in the CD ROMs' subassemblies. Thus, vertical integration connotes shared control of multiple stages of development, production and delivery through an electron-ically linked system.

"*Upstream*" and "*Downstream*" Economic Activities

An industry is said to be further "*upstream*" in the economy if its products and services flow through several intermediaries before they reach the ultimate customer. Thus, a firm that makes fuel injection devices is further upstream than the auto manufacturer that installs those devices in its cars. The dealership that sells cars to the public would be considered downstream from the auto manufacturer.

4.1(a) Competition in these technology-intensive industries is considered very *"time-sensitive."* That is, maintenance of a firm's market share is predicated largely by the speed at which it introduces new, and hopefully superior performing, products.

4.1(b) These industries characteristically use short production runs and "just-in-time" inventory control strategies. Rapid redesign, nearly real-time customization of products or services to individual customer specifications, and product differentiation are more critical to market shares within technology-intensive industries than are economies of scales in mass production and standing inventories.

See L. Katz, *Technological Change, Computerization and the Wage Structure* (unpublished paper prepared for the Understanding the Digital Economy Conference, 1999 at http://www.digitaleconomy.gov/)

4.2. To facilitate rapid response to changing consumer tastes and demands, there is a high degree of vertical integration throughout the chain of transactions from vendors to customers in technology-intensive industries.

4.2(a) With the exception of resource intensive extractive (e.g., oil and gas exploration, timber and mining) and agricultural enterprises, the further "*upstream*" the business or industry, the higher the probability of technology-driven changes in production.

4.2(b) Because they tend to be further upstream, these industries' technology-driven changes in production have large ripple effects throughout other sectors of the economy. (For illustrations of ripple effects, see pages 18 and 19.)

5. Productivity per worker in industries with the characteristics listed above tends to be high. That is, technology-intensive industries tend to have an above average output-to-labor ratio.

See Brynolfsson and Yang, *Information Technology and Productivity: A Review of the Literature* in Advances in Computers vol. 43 (1996).

5.1. Technology-intensive industries tend to have a low input/output (I/O) coefficient. An I/O coefficient compares the cost of raw materials or parts to the price of finished products. To put it another way, technology-intensive industries tend to be highly "value-added."

See Gera and Masse, *op. cit*.

5.2. Workers in technology-intensive industries tend to be paid more than the average for all sectors of the economy.

Note the circularity here. It is hard to separate cause and effect. Higher wages must be offered initially to recruit workers with advanced degrees that are in short supply. Therefore, periodic wage increases are provided to retain and reward those high-skill incumbent workers. By applying their advanced skills, these workers contribute to improved productivity across the industry. After deploying new automation tools and processes to further enhance their highly skilled workers' productivity, tech-nology-intensifying firms' usually realize higher profits. They can keep on plowing a portion of those profits into the payroll to meet subsequent demands for wage increases.

See Dunne, et. al. *Wage and Productivity Dispersion in U.S. Manufacturing: The Role of Computer Investment* (Washington, DC: Census Bureau, 1999); and C. Goldin and L. Katz, *The Origins of the Technology-Skills Comple-ment* in Quarterly Journal of Economics (August, 1998).

Again, static pictures of worker productivity and average earnings in an industry don't tell the whole story. If productivity or compensation is increasing at a faster rate than in most other industries, then technology probably is transforming the workplace. This transforma-tion impacts the knowledge, skill and abilities required among an industry's workers.

6. The market scope for the products and services of technology-intensive industries tends to be global.

6.1. A good indication of an industry's global competitiveness would be its ratio of exports-to-domestic sales. This ratio tends to be higher in the technology-intensive industries.

6.2. Technology-intensive industries tend to attract more foreign investments.

6.3. Technology-intensive industries compete globally for labor. That means low-skill as-pects of a technology-intensive industry's production can be relocated "off-shore" or out-sourced to wherever labor costs are lowest.

What industries exhibit these characteristics? Researchers in the United States often engage in circular reasoning. They assume *a priori* that industries which make computer and telecommuni-cations equipment, install it, support it and write application software for it constitute "*high tech*." The best work using empirical indicators to identify the level of technology intensity at the industry level comes from Canada and from the Paris-based Organisation for Economic Co-operation and Development (OECD). While non-American research entities use different industrial taxonomies and slightly different titles for each sector of their respective economies, it is easy to see parallels between the Canadian or the OECD's findings and patterns we suspect — on the basis of anecdotal evidence — are occurring in the United States.

Table I was reconstructed from several tables in Gera and Masse (*op. cit.*) to illustrate where various industries rank on several key indicators. Table II also is a composite reconstruction of several tables in Gera and Masse (*op. cit.*). It highlights their rating of Canadian industries accor-ding to their technology-intensity and knowledge-intensity. Taken together, these tables show how researchers in this country also might go about meaningful industry-level analysis of structural changes. Such analysis should be the first step in figuring out: a) why educational requirements are being rachetted upwards in some industries while they are declining in others; b) how changing educational requirements affect productivity and wages; and c) why some communities — based on their industry mix — are prospering while others are going into economic tailspins.

TABLE I

Key Indicators of Industrial Employment Composition in Canada

Industry (*using a Canadian industrial classification taxonomy*)	Percentage of R&D Professionals in workplace	Percentage of workers with postsecondary credential	Percentage of workers who are Scientists and Engineers
Top ranking industries in 1996 Canadian Study by Lee and Has			
Scientific & Professional Equipment	3.14%	45.3%	12.6%
Communications & Other Electronics	19.38%	37.6%	5.3%
Aircraft & Parts	11.17%	50.5%	14.8%
Computers & Related Services	6.36%	69.2%	42.0%
Business Machines	15.73%	59.6%	21.2%
Engineering & Scientific Services	4.99%	74.9%	62.1%
Pharmaceuticals and Medicine	5.39%	51.7%	10.0%
Other Chemical Products	3.16%	44.6%	11.2%
Refined Petroleum	7.94%	53.6%	15.6%
Other Electrical & Electronics	1.69%	33.9%	7.9%
Industries in the bottom tier of rankings by Lee and Has			
Construction	0.02%	36.5%	2.3%
Fishing & Trapping	0.11%	19.8%	2.2%
Food Stores	0.44%	23.9%	2.1%
Furniture & Fixtures	0.16%	26.1%	1.5%
Logging & Forestry	0.14%	29.6%	8.0%
Storage and Warehousing	0.06%	23.4%	1.0%
Agriculture	0.04%	21.5%	0.5%
Accommodations, Food & Beverage	0.02%	20.0%	0.1%
Amusement and Recreation	0.02%	34.2%	0.9%
Retail Trades	0.01%	28.1%	0.3%
Personal Services	0.02%	40.5%	0.1%

TABLE II

Rating of Canadian Industries by Level of Technology- and Knowledge-Intensity

Technology-Intensity and Knowledge-Intensity Index Rating		
High	Medium	Low
Professional/Scientific Equipment Communications and Electronic Equipment Computers, Business and Other Office Equipment Aircraft Assembly and Parts Scientific and Engineering Services Pharmaceuticals Health Care Chemical Products Petroleum Refining Management and Consulting Services Educational Services	Fabricated Metal Products Motor Vehicles and Parts Financial Institutions and Services Insurance Real Estate Accounting Services Printing and Publishing	Food and Beverage Service Amusement and Recreation Lodging & Accommodations Fishing and Trapping Logging and Forestry Storage and Warehousing Agriculture Retail Trades, Wholesale (other than professional scientific equipment and products) Personal Services Quarries and Sand Pits Leather Products and Footwear Retail - Clothing/Apparel Textiles and Garments Furniture, Fixtures and Wood Products

Note in Tables I and II, the titles the Canadian government uses in naming industries does not coincide exactly with the Standard Industrial Classification (SIC) taxonomy used by the United States Departments of Labor and Commerce.

Ratings of the knowledge- and technology-intensity of Canadian industries relies on the use of three composite indicators of R&D activities and two "human capital content" indicators. The three R&D indicators are: R&D expenditures; R&D personnel as a portion of total employment in the industry; and R&D personnel with a university degree as a portion of an industry's total employment. The two measures of human capital content are: ratio of workers with postsecondary education to total industrial employment; ratio of "knowledge workers" (mathematicians, scientists, engineers, managers, social scientists, lawyers and physicians) to total industrial employment.

- An industry is classified as "high-knowledge" if at least two of its three R&D indicators belong to the top third of all industries **and** at least one of its two human capital content indicators belong to the top third of all industries.
- An industry is classified as "low-knowledge" if at least two of its three R&D indicators belong to the bottom third of all industries **and** at least one its two human capital content indicators belong to the bottom third of all industries.
- All remaining industries are classified as "medium-knowledge" industries.

It is important to identify which technology- and knowledge-intensive industries are likely to drive the local economy because:

1) Technology-intensive industries tend to be the primary source of employment demand growth at the high wage end of the spectrum (though not necessarily the largest source of overall employment demand).

2) Employment demand growth in technology-intensive industries tends to be relatively immune to recession. To be sure, during a recession technology-intensive industries may have to downsize. However, during a recession, they will lay-off proportionately fewer workers — especially at the high wage end of their staffing patterns. Technology-intensive industries are apt to rebound more quickly and begin expanding faster as the recession comes to an end.

3) Technology-intensive industries tend to be net exporters of goods and services. That is, they tend to sell a disproportionate share of their goods and services to customers in other nations or other states. They generate a positive cash flow for the nation, state, region and communities in which they are located.

4) They are more likely to be immune — particularly at the high wage end of the staffing pattern — to trade adjustment lay-offs. (That is, the number of jobs created within a technology-intensive industry to meet foreign demands for its goods tends to be greater than the number of jobs the same industry loses when foreign firms' goods penetrate its domestic market.) They are apt to rebound more quickly to recapture market shares after successive rounds of market penetration by foreign competitors.

> Technology-intensive industries show a tendency to "think their way out of problems." They find ways to improve productivity, lower costs, further differentiate their product lines and deliver goods more efficiently rather than hunker down in the face of recession and the pressures of global competition.

The Impact of Strategies to Enhance the Technology-Intensity of Industries

All things being equal, technology-intensive industries afford the best prospects for economic development because increases in their economic activities tend to ripple throughout the balance of the economy. An increase in employment or earnings in these industries (which tend to be upstream in the supply chain) has a larger multiplier effect in that it creates additional employment demand, increases payrolls and stimulates more tax revenue generation in industries further down-stream. Table III illustrates how growth in an upstream, technology-intensive industry (like Semiconductor Manufacturing) has a greater ripple effect through the balance of the economy than would comparable growth in an industry with low technology-intensity further downstream (such as Retail Sales - Women's Ready to Wear).

TABLE III

Ripple Effect Illustration

Indicator of Estimated Ripple Effects (Annualized)	Scenario One: a Semiconductor Manufacturing and wafer fabrication firm (SIC = 3674) expands to hire fifty new workers.	Scenario Two: a chain that sells Women's Ready-to-Wear Apparel (SIC = 5621) opens an outlet and hires fifty workers.
Value of goods produced by the added workers in this industry.	$ 5,221,000	$ 1,528,000
Jobs added in other sectors of the economy to handle increased economic activity that results from the initial business start up or expansion	93	23
Additional economic activity in other sectors stimulated by the initial business start up or expansion.	$12,200,000	$ 3,100,000

The anticipated annualized ripple effects in the two scenarios depicted in Table III are derived from the Texas State Comptroller's Input/Output model. That model is based on the analysis of business-to-business transactions across the Texas economy.

It appears that, regardless of the indicator used, the ripple effects of an expansion of a semiconductor/wafer fabrication firm would be four times greater than a comparable increase in the number of workers employed in the sale of women's ready-to-wear apparel. The text box on the next page highlights some of the economic activities stimulated in other sectors. The hypothetical examples illustrate how the ripple effects play out differently in the two scenarios.

The Bottom Line for Industry-Level Analysis

Analysis of shifting employment demands at the industry level is the first step in drilling down through increasingly detailed levels of available data to understand the economic environment. An understanding of shifting industrial employment demand is most pertinent at the broadest policy levels: strategic planning and economic development. Before drilling down to firm-level data, we offer concrete recommendations based on industry-level analysis.

This industry level analysis is not intended to give leaders of various sectors bragging rights about driving the economy. Nor is this analysis intended to spark esoteric debates among economic historians about which indicator is most useful in explaining significant changes that occurred during the last decade. What is important is that decision-makers can use any one of the indicators or several in combination (depending on the availability of pertinent data) to assess economic change within the labor market where the policies they make will play out.

How Ripple Effects Play Out Across Various Sectors of the Economy

- selected highlights from the two scenarios on the previous page -

Ripple effects in an industry downstream from both Semiconductor Manufacturing and Retail Women's Ready-to-Wear Sales: anticipated economic activity stimulated in Eating and Drinking establishments.

Commanding higher wages than retail sales clerks, the fifty new employees at the Semiconductor Manufacturing firm would have more disposable income to spend in Eating and Drinking Establishments. Restaurants and bars in the community will add staff to meet increased consumption demands. Part-timers will be added in some bars and restaurants, full-time help in others — collectively totaling slightly more than 9½ full-time equivalents (FTEs). Far fewer food and beverage workers would be needed to serve consumption demands of fifty additional Retail Apparel Sales workers. If the community landed the retail outlet instead of the manufacturing firm, Eating and Drinking Establishments probably will add no more than 1½ FTEs collectively.

Revenues to Eating and Drinking Establishments generated by the purchases of the Semiconductor firm's fifty new employees would be in the neighborhood of $175,000 per year. Compare that to $30,000 in anticipated food and beverages purchases by fifty new employees of a Women's Ready-to-Wear store. These effects are compounded when the greater revenue generated by sales to the Semiconductor firm's employees are used by Eating and Drinking Establishments to buy more from Restaurant Supply Companies, Meat Product Wholesalers, Linen Supply and Laundry Services, etc. In addition, a larger portion of the anticipated increase in purchases among waiters and waitresses, cooks, etc. would be attributed to the earnings they derived from food and beverage consumption by the Semiconductor firm's fifty new employees.

Ripple effects in an industry upstream from Retail Women's Ready-to-Wear Sales but at approximately the same level as the Semiconductor Industry in economic transaction flows: anticipated economic activity stimulated in Other Electronic Component Manufacturing.

The addition of fifty employees by a Retail Apparel chain has almost no anticipated impact on the production and sales by Electronic Component Manufacturers. Only a $261 increase would be anticipated in the sales and production of Electronic Components. That would not necessitate any increase in employment in Other Electronic Component Manufacturing. However, because Computer Manufacturers downstream use Other Electronic Components in their finished goods along side semiconductors, a fifty person increase in employment by the Semiconductor firm would translate into an anticipated $78,200 increase in their sales and production. That magnitude of increased production would require the addition of approximately one FTE collectively across the Electronic Component Manufacturing Industry statewide. That single additional FTE added to the payroll of an Electronic Component Manufacturing firm would, in turn, stimulate additional economic activity through his/her purchase of things like food and beverages from Eating and Drinking Establishments.

Ripple effects in an industry upstream from both Semiconductor Manufacturing and Retail Women's Ready-to-Wear Sales: anticipated economic activity stimulated among firms that produce Other Industrial Chemicals.

A fifty person increase in employment by the Retail Apparel Store has virtually no impact on the Industrial Chemical Industry. In the Standard Industrial Classification (SIC) taxonomy, firms in the Industrial Chemicals Industry supply materials integral to manufacturing semiconductors. The I/O model, therefore, projects a $30,200 increase in product sales of Industrial Chemicals as a result of a fifty person increase in employment at the Semiconductor Manufacturing firm. No additional persons would have to be employed by any firm in the industry to meet a $30,200 increase in demand for Other Industrial Chemical products.

The critical points to remember are:

- Transformation of the economy from one based primarily on manufacturing to a knowledge-based one is an ongoing process. That process continues in fits and starts. It affects all sectors of the economy. Some industries are quicker to innovate; some are slower. The substitution of technology and knowledge for raw materials and physical labor is more pervasive in some industries than in others. This economic transformation, however, is not complete. That fact constitutes the fundamental reality about the economic environment which must be addressed by policy-makers. Industry-level analysis can tell us which sectors are poised to take-off. Forecasting at the industry level is essential to guide investment of economic development dollars for maximum returns to Texas communities.

> The indicators of technology-intensity overlap. Industries rated high on one indicator probably rank high on all the others.

- Because economic transformation is a global phenomenon, many decision-critical variables are beyond the control of state and local policy-makers. Some groups of workers, indeed entire industries and regions, may be more dramatically affected than others. Policy-makers may wish that this was not so. But no amount of wishful thinking will turn back the hands of time to halt the churning and dislocations. Decision-makers must be realistic. To be effective, their strategic plans to promote prosperity must be predicated on empirical analyses of ongoing economic changes. In particular, what we can learn by dissecting shifting patterns in industrial employment demand is an understanding of the unique comparative advantages each distinct labor market or specific community has to offer in the emerging knowledge-based economy.

The unmistakable inference to be made from an analysis of recent shifts in industrial employment is that the very nature of comparative advantages has changed. A manufacturing economy stresses mass production. Comparative advantages therein entail ready access to raw materials and transportation plus cheap labor. Changes that make transpor-tation more efficient were beginning to reduce the importance of location as a comparative advantage even before computers became so pervasive. Now knowledge itself has become a key commodity. Unlike most manufactured goods, knowledge can be packaged as digital signals that can be moved around the globe electronically. That makes proximity to natural resources and transportation hubs even less important. Given the shifts in economic activities identified previously, comparative advantages

> **Comparative Advantages**
>
> In the past, its location at the confluence of three rivers and proximity to the coal fields of Pennsylvania gave Pittsburgh comparative advantages in becoming the center of America's steel industry. Houston's deep water port and proximity to oil fields in South Texas gave it comparative advantages in becoming a center of petroleum refining.

are now rooted in innovation in the use of skills (people), capital (technology) and ideas (knowledge).

This creates an environment where scientific and technological innovation play a critical role in generating economic growth. Investing in knowledge-creating industries has become a viable alternative to strategies which rely on location or cheap labor in sustaining the long-run perfor-mance of a local economy. Industries which produce knowledge, on the other hand, are willing to pay a premium for education, training and experience. On the other hand, industries which rely heavily on unskilled labor find it more profitable to relocate wherever prevailing wages are lowest.

Strategies designed to accentuate new knowledge-based sources of comparative advantage are likely to yield better returns to capital and labor; produce substantial spill-over benefits (i.e., ripple effects) across other industries downstream; and stimulate even more economy-wide invest-ment. The underlying assumption of a sound economic development strategy is that policies targeted to encourage employment in knowledge- and technology-intensive, high-wage sectors are likely to shift labor from low- to high-productivity uses. After all, increased productivity is integral to economic growth and sustained prosperity in the new economy.

See Gera, S. and K. Mang. *The Knowledge-Based Economy: Shifts in Industrial Output*. (Ottawa, Canada: Industrie Canada, 1997).

The final point is that unless local decision-makers can figure out what comparative advan-tages their respective labor markets have to attract and expand knowledge- and technology-intensive industries, entire communities may be left on the bottom side of the digital divide. Lacking the digital infrastructure and proper educational support mechanisms to participate fully in the know-ledge-based economy, some communities — particularly isolated rural ones — may see high-paying employment opportunities dry up. They will experience a brain drain as their best educated and trained youths leave the area to find challenging and rewarding jobs elsewhere.

Recommendation #1: Revisit economic development strategies to maximize the local labor market's comparative advantages that are most relevant in a new knowledge-based economy.

To paraphrase David Osborne, economic growth should be the first item in any workforce development agenda. (See Osborne, *op. cit*. - especially Chapter 8.) Education and training strategies, job placement activities, implementation of "*work first*" welfare reform, and efforts to match individual characteristics, training and experience to occupational profiles all put the cart before the horse. All such efforts are for naught if the local economy isn't growing fast enough to absorb new job-seekers. Job creation has to be a top priority before other goals and objectives can fall in place. An understanding of comparative advantage derived from the analysis of shifts in industry-level employment demand is essential to a rational strategy for stimulating economic development and new job growth.

Examples of Industries Clustering Around an Area's Comparative Advantages

Microchip production and wafer fabrication facilities in Texas, for example, are concentrated heavily in the Austin metropolitan area. Communications equipment manufacturing is concentrated more heavily in the "Richardson Corridor" while biomedical technology firms are more concentrated around Houston because of the technology transfer that stems from the research and development leadership of M.D. Anderson Hospital and Methodist-DeBakey Hospital and the Nobel Prize winning work in nano-technology by Dr. Richard E. Smalley at Rice University.

It's always tempting to engage in well-intentioned boosterism in the naive belief that one's own community ought to be attractive to others. Economic developers often treat all industries as viable propects. But history tells us that job growth is more likely to result from efforts to: 1) expand businesses already operating in the community; 2) attract new businesses in closely related endeavors; and 3) increase the productivity and profitability of the older, established businesses as well as new ones.

We recommend that economic development efforts be targeted to increasing the technology-intensity or knowledge-intensity of industries already operating in the local economy. The six criteria listed previously in the analysis of shifting industrial employment patterns can be used to identify which industries in the local economy are moving up the scale of knowledge- and technology-intensity. Use those indicators to define and anticipate which industries in your community are poised for take-off.

The pay-off for such a targeted economic development strategy is likely to be higher than for a shotgun approach or a strategy based on luring businesses that merely are searching for cheap labor. Fostering increased knowledge- and technology-intensity in an industry tends to raise the average wages in that industry. Larger ripple effects are triggered throughout the local economy when an expanding business procures more goods and services from other firms in the community and its workers have more purchasing power. And as local businesses use knowledge and technology to diversify and become more productive, the community as a whole becomes more prosperous, more resilient in the face of recession and more capable of withstanding global competition.

See T. J. Bartik, *Economic Development Strategies* (Kalamazoo, MI: W. E. Upjohn Institute, 1995); and E. Sternberg, et. al., *Rethinking State and Local Economic Development Strategies* (Albany, NY: Nelson Rockefeller Institute of Government, 1993).

Recommendation #1(a): Validate the structural changes in various sectors of the economy locally. Identify your area's unique comparative advantages to fine-tune a targeted economic development strategy.

Technology- and knowledge-intensive industries are not spread uniformly across all sub-state regions. Firms that fit together in a vendor/producer supply chain — even competitor firms — tend to cluster together in an area whose comparative advantages are important to a particular industry. Firms similar to those already thriving in an area are the most likely to be attracted to and expand in that same area. However, demand for the products and services of any given industry can not be expanded infinitely. Industry growth can reach a saturation point beyond which additional efforts to stimulate growth result only in more churning.

In Economic Development, There Is No "One Size Fits All" Strategy.

Just because Professional and Scientific Equipment Manufacturing (both at home and abroad) leads the list on nearly every indicator of technology- and knowledge-intensity, that doesn't mean every community can hope to grow its economy around that industry. Just because phenomenal economic growth in the Austin metropolitan area was fueled largely by Electronic Component, Microchip and Computer Equipment Manufacturing firms doesn't mean that every community in Texas will succeed in recruiting firms in those same industries. **Each community must devise an economic development strategy tied to its own unique comparative advantages** rather than assuming that what worked elsewhere will work equally well for them.

The Shift-Share module in SOCRATES (an automated labor market targeting package available on the Internet from Career Development Resources) can be applied to regional data. It helps users determine which subset of industries are best able to exploit an area's comparative advantages. (SOCRATES can be found at http://socrates.cdr.state.tx.us.) For some substate areas, the industries we conventionally think of as "*high tech*" won't top the region's Shift-Share list. Strategic planners must determine what comparative advantages are evident for the community's dominant growth industries. To sustain the local economy and spark additional growth, decision-makers must figure out how investments in increased technology- and knowledge-intensity in the community's existing industries might improve their productivity and global competitiveness.

There is a general pattern in the affinity of certain types of industries locating in the vicinity of particular kinds of comparative advantages. Natural resource-intensive industries tend to locate near the source of raw materials and around transportation hubs. Service industries tend to cluster in large population centers to be close to their customers. Industries which rely largely on unskilled labor simply locate where wages are lowest. A community's tax structure weighs heavily in locational decisions of capital-intensive industries. The primary consideration for knowledge- and technology-intensive industries tends to be the education and training of the local labor force. **A prudent economic development strategy must strike a balance between the comparative advantages the community has to offer and a vision of what kind of industry it wants to attract.**

Clustering vs. "One-Size-Fits-All" Hi-Tech Development

After studying fourteen "high-tech" metropolitan areas, a research team from the Brookings Institution concluded that, contrary to common wisdom, high technology companies vary dramatically from place to place. The comparative advantages of an urban region favor only a very few industries. Different metropolitan areas tend to specialize in certain technologies and have major concentrations of firms in relatively few product categories. A region that is strong in one specialized field (e.g., biomedical technology) doesn't necessarily have a competitive advantage in another (e.g., semi-conductors). Thus, binary classifications of industries — labeling industries either as high tech or not — aren't very useful. Because high tech firms aren't homogenous, different strategies emphasizing different comparative advantages are necessary to attract each kind of specialized cluster. Aside from San Jose, California, none of the fourteen high tech centers studied by the research team was home to a broad range of high tech firms. Using several "location quotients" (measuring the degree of concentration of employment, patents and venture capital), researchers from Brookings Institution found the following:

Austin, Texas has nearly five times the national average for per capita employment in computer and electronic product manufacturing but slightly less than the national average for major metropolitan areas for employment in Information Services and Data Processing Services. Austin leads the other thirteen cities in the study with higher than average concentrations of patent holders in Information Systems, Data Processing Organization, Computers and Data Processing Equipment, and Semiconductor Device Manufacturing Processes. Austin is second only to Seattle in patent holders in Computer Graphics Processing but is near the bottom among the fourteen high tech centers in patent holders in Microbiology, Chemistry and Molecular Biology.

Washington, DC, Denver, and Atlanta are known as software centers but are relatively weak in hardware. Conversely, Phoenix is strong in hardware, weak in software. Raleigh-Durham, NC and Washington DC have higher than average concentrations of biomedical firms. Boston and Minneapolis specialize in mainframe manufacturing. In each case, one or two market-dominating firms serve as anchors for an area's field of specialization. American On Line and MCI, for example, serve as the anchors for Washington DC's concentration of Internet servicing firms. In the heyday of mainframes, DEC, Wang and Data General anchored mainframe manufacturing in Boston while Control Data, Honeywell and Unisys did the same in Minneapolis.

Conclusion:

Decision-makers should avoid replicating generic development strategies. Disparate high technology firms respond to the distinctive knowledge base of the existing workforce and firms and a region's special characteristics. Economic development efforts should be tailored to build on or extend existing strengths or emerging local competence; trying to create a totally new high tech center where none currently exists is likely to be a lengthy, and probably fruitless, endeavor.

J. Cortright and H. Mayer, *High Tech Specialization: A Comparison of High Technology Centers* (Washington, DC: Brookings Institution/Center for Urban and Metropolitan Policy, 2001).

Recommendation #1(b): Don't overlook the potential of less glamorous and relatively low tech industries poised for take-off and favored by the area's comparative advantages.

David Osborne (*op cit.*) warns against falling into the trap of false dichotomies. Do not think in terms of the service sector versus manufacturing as the engine of growth. In Osborne's words, "The real target ought to be innovation in **all** businesses — of all sizes and ages [in any sector]. . . Like manufacturing and services, '*high-tech*' and '*basic*' industries are not separate categories we can choose between [freely]. In competition with low-wage labor in other nations, [any American] industry can remain competitive only if [it] move[s] systematically up the quality ladder into sophisticated products that cannot be produced in the Third World."

Take Deep East Texas, for example, where the Timber Industry traditionally has been dominant. Logging and Forestry along with Furniture and Wood Product manufacturing commonly are ranked at the low end of any knowledge- or technology-intensity scale. Nonetheless, efforts to up-skill production and marketing in these fields might give Deep East Texas a competitive edge.

It is unlikely that a Furniture Manufacturer in Deep East Texas could compete on price with goods mass produced in North Carolina or off-shore. However, a Deep East Texas firm might be able to compete more effectively through rapid product differentiation. That is, a nimble firm could compete at the high-price end of the furniture market by filling the niche demand for unique, custom-tailored pieces. While final assembly and finishing would still be done by craftsmen working with traditional tools, rapid response to individual design specifications from customers around the world could be expedited by a web-based advertising and order-taking system. Response time could be reduced if the order-taking system tied directly to computer numeric controlled (CNC) pattern generation and automated preparation of rough-cut materials. Profits could be enhanced through supply chain integration for just-in-time inventory deliveries from lumber and hardware wholesalers.

Making Due with What You Have

The Permian Basin has a surplus of tumbleweeds. With a bit of ingenuity, a businessman from Odessa figured out how to turn tumbleweeds into bronze curios. They became a hot item for export to Japan. The highly lu-crative enterprise hinged on the application of chemical processes and the science of electro-plating. The entrepreneur used the Internet to reach a foreign market. Overhead was low because he located operations in a facility that had been vacated during the economic down-turn in the petroleum industry in the mid-1980s.

A meat packing plant in the Rio Grande Valley, through Internet advertising, found it could command higher profits by marketing fajitas to Japan as exotic Tejano cuisine. Another meat packing plant in South Dakota — through web-based research — realized that the offal they had been giving away to a local rendering plan could be sold to customers in Saudi Arabia as a delicacy.

Recommendation #1(c): Fit local economic development initiatives into a broader regional master plan.

Industry-level analysis of rural economies is likely to show stagnation and declining employment. When the prevailing news appears to be bad, it's hard to identify any comparative advantages. Indeed, economic development (as traditionally conceived) most often happens in urban areas. Thus, the state's economy is, in the words of Jane Jacobs, a series of regional economies that radiate out from the major cities. Venture capital and entrepreneurship are more likely to come together in urban areas that benefit from the intellectual infrastructure and technology transfer networks of the flagship research universities. Thus, urban areas are the focus of most large scale publicly funded pump priming initiatives. The economic fates of rural areas and small towns depend largely on business and industry activities in the nearest metropolitan areas. Rural communities tend to supply the food, the raw materials, recreational outlets and perhaps some components of final goods assembled in the cities.

> See Osborne, *op. cit*., for an economic development perspective on theories and research done earlier by Jane Jacobs in *Cities and the Wealth of Nations* (New York City, NY: Vintage Books, 1985). Also see scales developed by the U.S. Department of Agriculture's Data and County Codes on Urban-Rural Commuting Area Codes with Commuting Zone and Labor Market Area Codes, Rural-Urban Continuum Code, and the Urban Influence Code at http://www.ers.usda.gov/briefing/rural/data/index.htm/

The best strategy for rural areas is to build linkages to and piggyback on the economic development efforts of neighboring urban centers.

- A small tool-and-die maker or metal fabrication shop in the Hill Country — perhaps with a loan from the Small Business Administration and technical assistance in marketing from a local economic development entity — could produce the kind of subassemblies that large computer manufacturing firms in the Austin metropolitan area currently buy from more distant vendors. (See, for example, the website of the U.S. Department of Agriculture's National Rural Development Partnership for information on grants and resources.)

- Communities on the Gulf Coast in Aransas County could expand their economies by offering recreation and respite through advertising targeted to urban-dwellers from Corpus Christi. Coastal communities in Matagorda County can tie their economic growth in the same way to burgeoning Houston.

> See the U.S. Department of Agriculture's county level data on natural amenities as comparative advantages at http://www.ers.usda.gov/briefing/rural/data/index.htm/ amenities. Also see D. McGranahan, *Natural Amenities Drive Rural Population Change* (1999) at the U.S. Department of Agriculture's Economic Research Service website at http://www.ers.usda.gov/epubs/.

- Because they are within an easy commute from acute care facilities like M.D. Anderson and Methodist-DeBakey Hospitals, communities in Waller, Montgomery and Fort Bend Counties might be ideal locations for hospice care and nursing homes for the chronically ill.

Recommendation #1(d): Footloose industries should be considered fair game for any community's economic development efforts.

Advanced computing and telecommunications technologies sparked the emergence of the new knowledge-based economy. Ironically, advances in these fields also rendered location totally irrelevant as a comparative advantage for some leading-edge industries. Industries for which location has become irrelevant are called "*footloose*." Companies that develop software, for example, can locate almost anywhere because their products can be shipped around the globe almost instantaneously via worldwide digital networks.

Examples of Footloose Industries	
1. A software company can develop products around the clock working in shifts in different countries in different time zones. An Indian programmer, for example, may start writing lines of code for a sub-routine at 8:00 AM New Delhi Time. At quitting time, the Indian passes hundreds of lines of code to an Irish programmer who starts testing and debugging them at 8:00AM Dublin Time. The Irish debugging specialist, in turn, passes the final product to a technical writer in San Jose, California. The technical writer starts drafting end-user instructions or pop-up help screens at 8:00AM Pacific Time.	2. If you call a toll-free number to make an airline reservation after normal business hours in the USA, your call might be taken in New Zealand, Singapore or Belfast. Communications satellites, packet switching and world-wide system linkage technologies free reservation operations from the need to locate close to their primary customer base — thus making it a "footloose" industry.

Quality of life and lifestyle options may serve as the primary factor in the decision by a company in a footloose industry to locate in one community rather than another. A rural community might be more attractive as a place to set up software development operations or a telephone "hot-line" support center. Key staff members with families may prefer to live where the crime rate is low, the public schools have a reputation for high-performance and traffic is not congested. Rural com-munities may be especially attractive if the cost of housing has not been driven beyond the reach of a company's production workers by rapid population growth.

See McGranahan, *op. cit.*; F. Carirncross, *The Death of Distance* (Boston, MA: Harvard University Press. 1997); and N. Negroponte, *Being Digital* (New York City, NY: Alfred Knopf, 1995).

Recommendation #2: Recognize the utility of indirect strategies for economic development.

Traditional economic development activities usually focus on recruiting specific firms to locate or expand operations in a community. An alternative, indirect approach would focus on improving a community's overall infrastructure (i.e., capacity-building) to attract new businesses and hold onto the established ones. Some economists have called this the "*Field of Dreams"* strategy. Paraphrasing the words of Shoeless Joe Jackson: "*If you build it, they will come*."

Recommendation #2(a): In addition to addressing the needs of specific firms, improve the community infrastructure to build future capacity for economic expansion.

We typically think of infrastructure improvements for communities outside major metropolitan areas in terms of upgrading the highways that link them to neighboring urban population centers or upgrading regional airports to facilitate more commerce with distant markets. Infrastructure improvements also can include wiring a com-munity (or at least several prime business loca-tions) for broadband to expedite e-business.

Access to broadband communications is to a business enterprise in the new economy what good running shoes are to the high-performance marathoner - a necessity, not a luxury. However, in most small towns and rural areas, consumers and businesses don't have high-speed connectivity. Small and medium size enterprises (SMEs) in urban areas may not have that option either. Differential access to high-speed on-ramps to the information superhighway by location and size characterize the "*other digital divide*." Unlike the nation's largest firms, most SMEs — especially in small towns and rural areas — still use the equivalent of an electronic dirt road.

Broadband Access in Perspective

A simple comparison of download times illustrates the superior speed of broadband. Using a conventional 28.8Kbps modem, it would take 42½ hours to down-load the entire *Titanic* movie. Using a cable modem at 10 Mbps, it would take 7¼ minutes.

Whereas 28.2Kbps might be considered adequate for most consumer uses such as Internet shopping, e-business uses (such as telecommuting, distance learning, local website hosting and telemedicine) often require as much as 6Mbps speed.

Lack of high-speed connectivity significantly restricts the ability to compete in a global economy. High-speed connectivity, for example, is a basic requirement for any firm engaged in a technology-related business as well as for the "backroom" operations of a more traditional kind of business. A telemarketing operation that sells magazine subscriptions may have as much need for high speed communications as a call-in support center for a software publishing firm. High-speed access is to the knowledge-based economy what access to a river, railroad or harbor was in yesteryear. High-speed, broadband access to the Internet effectively trumps other quality of life issues when communities try to attract footloose industries.

Most studies that look at Internet access as a defining characteristic of the digital divide miss a crucial fact. They focus on consumer uses (e-commerce) rather than on e-business (business-to-business interaction over the world wide web). Access to the Internet at any speed usually is considered good enough by casual users engaged in e-commerce. However, high speed and multimedia capabilities of broadband provide genuine competitive advantages in the business world. Why do economists dwell on the distinction between the needs of e-commerce and e-business? From an economic perspective, e-business access is by far more important. Whereas e-commerce is expected to reach $43 billion per year by 2003, e-business is expected to top $1.3 trillion. Meeting the needs of e-business is more crucial to overall economic development.

"First Mile - Last Mile" Considerations

For most of the journey to work, Benjamin Dover travels 15 miles on a four lane highway and Interstate 35. The speed limit on highways in an urban area is 60 mph. Ben's total commute, however, is not done at 60. He lives on a cul-de-sac at the end of a half mile long caliche lane that must be traversed at 15 mph. He has a half mile drive on a two lane county road before he reaches the four lane highway. The speed limit on the county road is 45 mph. Because there is no traffic light at the intersection of his county road and the four lane highway, he often sits for several minutes waiting to merge into westbound traffic. As Ben nears his office, traffic slows at a congested bottleneck on the Interstate. He takes an exit ramp where the speed limit drops to 35 mph then turns on to the office complex driveway that has speed bumps that effectively reduce speeds to 10 mph. Ben's total commute time is affected as much by the congestion and speed limitations in his first and last miles as it is by the speed limits posted on the major highways.

An analogy can be made to the Internet. We commonly think of the World Wide Web as a monolithic, undifferentiated, high-speed communications network — as one big information super-highway. But all parts of the Web were not created equally. Yes, the speed of information along the electronic backbone between major host servers is extremely fast. But from an end-user's perspective, the utility of the Internet is no better than the ease of connection and transmission speed in the "first and last miles." Austin, for example, is rated as one of the most "wired" cities in the nation. Thousands of miles of fiber optic cable have been laid in Austin to give businesses and consumers high speed/low cost access. It is a totally different story in Giddings — 50 miles east of Austin. Residents of Giddings must make relatively expensive long distance calls each time they want to connect to an Internet access provider. More importantly, they don't have the choice of high speed service because fiber optic cables haven't been laid that far.

The private sector is slow to serve the infrastructure needs of small towns and rural areas because of three factors called "*DDT*" (i.e., distance, density and terrain). DDT affects the cost of building and maintaining networks of any kind — railroads, highways, pipelines, electric power or telecommunications. Private companies "*cherrypick*" or "*cream*" areas where profit potential is greatest. They avoid areas with long distances between populations centers, low population density and difficult terrain. It may require action by public or quasi-public economic development entities in rural areas to get much needed infrastructure improvements. Without such improvements, rural communities have little chance of attracting and holding on to the kind of footloose industries that can thrive in a knowledge-based economy.

A Small Town Gets Wired: A Texas Success Story

Commerce, Texas (population 8,000) is about an hour's drive northeast of the Dallas Metroplex. Like other rural communities, Commerce struggles to grow its economy and stem the brain drain of its talented youths to larger cities. Community leaders realized their town needed access to high speed, broadband communications if it expected to compete in a global economy. (For example, the Commerce Economic Development Corporation noted that in 1998, six new business prospects decided to locate elsewhere because they considered the local telecommunications infrastructure inadequate.)

The city's educational institutions and its small regional hospital were connected to the "outside world" through high speed T1 lines. However, those lines were dedicated to specific uses. It would have been cost-prohibitive for most small businesses and residential users to obtain their own dedicated lines. Therefore, the City of Commerce repeatedly exhorted the local telecommunications carrier to switch to fiber optics so it could provide high speed/lower cost Integrated Services Digital Network (ISDN) and/or Digital Subscriber Line (DSL) options.

The local phone comapny chose not to upgrade capacity. The City of Commerce joined Troup, Palestine and Gatesville to intervene formally through the Public Utility Commission (PUC) to protest "quality of service problems" regarding the local carrier's decision to not offer ISDN or DSL connectivity. However, the process for addressing formal protests is long and drawn out. Community leaders had no assurances that the PUC could or would provide any remedy. Pessimistic about getting a prompt and positive resolution of those cities' joint petition, a consortium of public entities and private for-profit firms was formed, the Commerce Community Network (or CCN), to pursue alternatives.

The CCN is comprised by Texas A&M University-Commerce (TAMU-Commerce), Commerce Independent School District (CISD), the City of Commerce, the Chamber of Commerce, the Commerce Economic Development Corporation, the Commerce Public Library, the Boys and Girls Club, Presbyterian Hospital of Commerce, and Koyote Communications, Inc. (the service provider). TAMU-Commerce took the lead through its Technology and Distance Education Division. It agreed to: serve as the fiscal agent; provide backup expertise through its access to the statewide intellectual resources of the Texas A&M University System; and donate in-kind the services of Mary Hendrix to be the CCN's executive director and chief grant proposal writer.

The CCN applied to Texas's Telecommunications Infrastructure Fund Board for a grant to develop a fiber optics backbone (Metropolitan Area Network - MAN). The CCN's institutional partners provided $372,108 in local funds and in-kind matches to show their *bona fide* intention to establish, sustain and make optimal use of the infrastructure improvements. Koyote Communications Inc., purchased and installed $1,250,000 of DSL switching and computer equipment at the terminus of the MAN. Because it took the initiative and mobilized community support, the CCN received $500,000 over a two years to bring much needed high speed, broadband connectivity to Commerce.

The CCN's action plan is a model for other rural communities' economic development through infrastructure improvements. This model proved to be a win-win opportunity for all stakeholders. The institutional partners, the private for-profit partners and the community all benefit. (Some of the benefits are highlighted below but the list is not exhaustive.)

What do the private for-profit partners get?

Koyote Communications, Inc. is required to host a community website for free. It must abide by CCN by-laws regarding website content, fair pricing and service quality standards. In exchange, Koyote is granted easements by the City. The CCN assisted Koyote in securing legal approval from the FCC to be a local telecommunications exchange carrier. Koyote can generate revenue through fees for installation and subscriptions from businesses and individual residents, banner ads on the community website, professional website development and technical assistance to local businesses that want to engage in e-commerce. Koyote also benefits indirectly insofar as the CCN's outreach and technology training efforts stimulate demand in the community for those revenue-generating services.

Like many other small, rural communities in Texas, Commerce was under-served in terms of physician coverage. Now **Presbyterian Regional Hospital** will have the capacity to engage in telemedicine. General practice physicians affiliated with the hospital can consult electronically with specialists and research facilities around the world. They can link electronically to pharmacies. They can monitor hospitalized patients and home-bound chronic cases from portals in their own offices. Staff can get the continuing education credits they need locally through distance education without incurring significant travel expenses and with far less loss time to the hospital.

What do the institutional partners get?

The City of Commerce will wire City Hall plus the police and fire departments to improve services. Mapped information will be stored digitally for rapid access when contractors seek permits that require zoning board approval, excavation permits and utility hook-ups. Dissemination of information about requests for proposals, procurement contracts, ordinances, council meeting minutes, workforce development initiatives, and public employment job postings has been automated.

Commerce Independent School District (CISD) administrators now communicate more effectively with parents about upcoming events and about their children's performance and attendance. Instructional services have been extended into evenings, weekends and the summertime to reach adult learners, dropouts and regular students. CISD can access supplemental curriculum materials, and distance education opportunities — especially adaptive curriculum for students with special needs and advanced courses for the gifted and talented. CISD can integrate the local curriculum with web-based materials to meet the state's technology education requirements in the Texas Essential Knowledge and Skills (TEKS). Instructional faculty take advantage of on-line continuing education opportunities for their own professional development. Eventually, CISD could eliminate its costly T1 line leases.

TAMU-Commerce improved its Computer Science degree and E-commerce Certification programs. It established a Research Center for Excellence in E-commerce. It now serves as the base of distance learning operations for the Northeast Texas Technology Academy (NTTA) to serve the needs of all school districts in Hunt County and 57 small, rural districts in the surrounding area that lack the student population base and resources to offer a diverse technology training curriculum. Internships, work-study slots, help-desk learning experiences and post-exit employment opportunities have opened for students. TAMU-Commerce also might eliminate its costly T1 line leases.

The **Commerce Economic Development Corporation** and the **Chamber of Commerce** are more effective now in recruiting new businesses and helping existing businesses flourish through e-commerce. In particular, special efforts are being made to assist historically underutilized businesses become more competitive.

What does the community at large get?

The improved telecommunications infrastructure serves as an economic catalyst for Commerce. The economy is growing as local businesses reach larger markets through e-commerce. They can be more responsive through more efficient supply-chain communications. Commerce has gained stature as an important player as firms start to spread beyond the very congested Richardson-Plano Telecom Corridor into the Silicon Prairie. Commerce always could offer affordable commercial and residential properties, less congestion and amenities that appeal to the lifestyle aspirations of many high tech workers. Now with improved infrastructure capacity, Commerce can compete even more effectively.

In the near future, residents will receive more responsive services from city government. Health care will be improved through telemedicine, a data warehouse of critical medical information mapped to guide Emergency Medical Services response and an electronic "*Ask a Nurse*" initiative. Koyote's public website features a comprehensive calendar of community events, access to local businesses' websites and employment opportunities. The CCN reaches out through workshops to make residents aware of high technology services and to make them more fluent in information technology. Special efforts are being made to reach under-served communities through a train-the-trainer initiative. Once trained, "*disciples*" and "*champions*" from faith- and community-based organizations help educate their congregations and neighbors. Experienced and trained TAMU-Commerce students provide website development services on referral and help desk support.

For residents who don't subscribe to any Internet services, public access stations are available: 14 are provided through collaboration between the Boys and Girls Club and the public library; Presbyterian Hospital set up a kiosk; computer terminals with Internet access are available during evening hours and on Saturdays on all four campuses of CISD and at TAMU-Commerce. In addition, the CCN provides technical assistance and incentives for businesses to donate computer equipment to churches and community-based organizations in minority neighborhoods.

An Illustration of the DDT Factors

The population density of New Jersey is greater than 800 persons per square mile. Population density is less than 100 persons per square mile on average in Texas. Consider, too, that the population in Texas is concentrated in urban centers like Dallas-Fort Worth and Houston-Galveston. Some rural counties have a population density of less than one person per square mile. It would take less fiber-optic cable, for example, to link thousands of workers in high rise offices in a densely populated New Jersey city or in Houston than it would to link a single Texan in Alpine to another Texan in El Paso. Which area would you choose to serve if you owned a cable television company? What is the incentive for private for-profit firms to serve the infrastructure needs of rural Texas?

See P. Burgess and F. Raitano, *The Other Digital Divide* (Denver, CO: Center for the New West, 1999); Tennessee Valley Authority and the University of Kentucky through http://www.rural.org/workshops; H.F. Gale, *Is There a Rural-Urban Technology Gap?* (Washington, DC: U.S. Department of Agriculture Economic Research Service, 1997); and *Atlas of Cyberspace* at http://www.cybergeogra-phy.org/.

Recommendation #2(b): Provide technical assistance to help all local businesses get involved in existing technology transfer networks.

In a global economy, truly competitive firms are those which are most nimble in responding to diverse and changing consumer demands. Quick response necessitates using the latest tools of the trade to monitor market trends. It also may entail speedy acquisition of patents, copyrights and trademarks or a rapid infusion of venture capital to upgrade production facilities.

Community leaders — especially in small towns and rural areas across Texas — could help existing firms and start-up businesses by taking an indirect approach to economic development. A business resources unit might be established within a local one-stop workforce center. A computer in the center's resource library might be dedicated to linking employers to information sources such as the US Patent Office, federal and academic technology transfer offices and government agencies that fund community development and infrastructure capacity-building. (See a partial list of technology transfer information resources in the Appendix of this report.) TWC should look into the possibility of earmarking a portion of federal Workforce Investment Act (WIA) dollars for funding such employer services.

At least one staff person at each center should be trained as the resident expert/facilitator. The resident expert could produce a monthly newsletter alerting local businesses of Request for Proposals from organizations like the National Science Foundation or the US Department of Commerce that fund business partnerships with research scientists to move new technologies from the laboratory to the marketplace. Staff could help employers complete paperwork to obtain tax incentives for upgrading production facilities (in enterprise zones for example) or to justify hiring high tech alien workers on H1-B visas. They could assist local companies make application for firm-specific training (e.g., from the Texas Skills Development Fund, SmartJobs, Self-Sufficiency Fund or the federal Skills Gap Training Fund) to prepare their workers to master new technologies as they are brought into the workplace.

> See H. Etzkowitz, *Public Venture Capital: Government Funding Sources for Technology Enterprise* (New York City, NY: Harcourt and Brace, 1999); Etzkowitz, et. al., *Capitalizing Knowledge: New Intersections of Industry and Academia* (Albany, NY: State University of New York Press, 1998); Etzkowitz and Leydesdorff, *Universities and the Global Knowledge Economy: A Triple Helix of Universities-Industry-Government Relations* (New York City, NY: Printers Publishing Ltd., 2000).

Staff at the workforce center might maintain a library and develop road maps to help new or expanding businesses navigate the overlapping (and sometimes confusing) maze of zoning ordinances, construction permit and operating licenses. They might conduct periodic community audits to identify and map assets (e.g., infrastructure, existing businesses, available retail and commercial space, vacant property zoned for commercial or industrial uses — and especially educational services and the supply of well educated and highly skilled workers). If this information is on file in a central location, well organized and updated regularly, the community can respond rapidly (without a hastily contrived survey) to information requests from firms making location decisions.

> Shorter product life cycles put pressure on companies to bring new products to market quick-ly in order to remain competitive. As a result, the need to select locations and be "up and running" in a short time is crucial for businesses seeking to preserve their market advantage. Corporations are in such a hurry that communities are expected to be ready to go (zoned, built, and fully wired) within six months of a company's location decision.
>
> N. Cohen, *Business Location Decision-Making and the Cities* (Washington, DC: Brookings Institution Center on Urban and Metropolitan Policy, 2000).

Local businesses and the community's economic development entity might take steps to help an educational institution in the area serve as the catalyst or go-between for technology transfer. Even if the local institution is a community college or a small branch campus for one of the state's flagship universities, an endowed chair might be offered to someone as a joint appointment in Business Administration or Marketing and a scientific or technical field. (Communities without a postsecondary institution might revise and expand the function of the local Agricultural Extension or Engineering Extension Office.) The endowed chair or extension agent might provide short courses on Entrepreneurship and Micro-Enterprise in addition to providing technical assistance on economic development and technology transfer. With the educational institution or extension office as a base of operations, this quasi-public official could serve as the area's chief grant proposal writer, partnership organizer or catalyst. Such alternative approaches are especially important to small towns that may not otherwise have an economic development officer.

> See Aspen Institute, *Developing Entrepreneurial Economies in Rural Regions* (Washington, DC: Aspen Institute, 1996) and See also J. Kayne, *State Entrepreneurship Policies and Programs* (Kansas City, MO: Kaufman Center for Entrepreneurial Leadership, 1999).

Recommendation #2(c): Consider underwriting business incubation activities.

Rural economic development efforts targeted to footloose industries are most likely to attract micro-enterprises — small start-up companies or spin-offs from large firms. Despite having good ideas for new consumer goods or more cost-effective production, many micro-enterprises fail in their first few years. Too few small new ventures immediately generate enough revenue to meet their start-up costs, payroll and overhead expenses. An economic development entity might make the situation more attractive to start-up entrepreneurs by providing incubation services:

Assistance in securing start-up financing:

- help entrepreneurs connect with local venture capital brokers
- help start-up firms apply for grants or loans from entities like the Small Business Administration or US Department of Agriculture's Rural Development Business Partnership Programs (see Appendix I for SBIR and SBTT grant information)
- provide direct loans at low interest and/or with a deferred payment schedule
- subsidize rents for office space in a business incubation center or an industrial park
- perhaps co-locate start-up firms in a building that houses the economic development and/or the local one stop workforce center
- locate in an enterprise zone or in a historic building to qualify co-locators for financial assistance in facilities preparation — particularly for grants to help with the cost of wiring the premises for high speed broadband access.

Developing cooperative arrangements for sharing the costs with other co-located micro-enterprises for:

- office equipment, high speed/high capacity network server and wiring the premises for high speed broadband access
- leveraging quantity price breaks through joint supply procurement or common site licensing of application development programs or software packaged together as office suites
- reduced costs for bookkeeping and clerical services from a shared pool.

Technical and legal assistance in obtaining investment tax credits or qualified vendor status to enter contracts with public agencies.

Recommendation #2(d): Collaborate with other stakeholders to remove barriers and speed up the entire process of technology transfer.

The Texas economy as a whole would be more nimble and responsive if barriers to technology transfer were removed. Many barriers to economic development in Texas stem from the rules of conflict of interest, conflict of commitment and intellectual property rights imposed on researchers in the state's public postsecondary institutions.

The impact of various educational institutions' technology transfer policies are discussed in more detail in *Academic Capitalism* by L. Leslie and S. Slaughter (Baltimore, MD: Johns Hopkins Press, 1999); and the several works of H. Etzkowitz cited in this report's bibliography.

See also Branscomb and Keeler, *Investing in Innovation* (Cambridge, MA: MIT University Press, 1997); D. Greenberg, *Science in the Public Sector* Chronicle of Higher Education (January 19, 2001); J. Bassinger, *Universities are Urged to Promote More Research Ties with Industry* in the Chronicle of Higher Education, June 11, 2001; Business-Education Forum, *Working Together, Creating Knowledge: The University-Industry Research Collaboration Initiative* at http://www.acenet.edu/pdf/workingtogether.pdf (2001); R. Nelson, *Sources of Economic Growth* (Cambridge, MA: Harvard University, 2000), R. Ehrenber, *Supply of American Higher Education Institutions* at http://www.ilr.cornell.edu/cheri/wp11.pdf (April 2001) and R. Ehrenber and J. Epifantseva, *Has the Growth of Science Crowded Out Other Things at Universities?* at http://www.ilr.cornell.edu/ cheri/wp12.pdf. For one institution's unique solution, see K. Brichard, *Research Center in Ireland Will Share the Wealth with Staff Members,* Chronicle of Higher Education (December 13, 2000).

Rules and Regulations Impeding Technology Transfer in Texas

Most public universities have rules and regulations regarding conflict of interest and conflict of commitment that cover faculty and staff members' collaboration with for-profit private sector interests. For example, a salary theoretically covers all institutionally assigned duties and tasks for 100% of a faculty member's time. A faculty member is not supposed to be compensated for more than 100% of his or her "time" in the workday. Assume a faculty member receives a grant to conduct research from an external entity. If any portion of the grant is used to compensate the faculty member, current rules require a proportionate reduction in the salary paid from the institution's coffers — thus reducing faculty incentives to go after external grants.

If patents or copyrights are obtained as a result of research conducted on campus by a faculty member, the institution may demand an exorbitant portion of any royalties or profits from future market transactions.

These two factors reduce financial incentives for faculty to collaborate with private enterprise to push ideas from bench science into the workplace or consumer's shopping cart. Other rules and red tape complicate the use of and institutional fees charged for laboratory equipment or space used by faculty in joint ventures with profit-making entities.

The burdens imposed by the rules governing Texas public postsecondary institutions have led enterprising science and engineering faculty to resign. Some have found more "entrepreneurial-compatible" environments in the private sector. Other have been recruited by research universities in other states where the rules overtly encourage entrepreneurial spirit.

Illustrations provided by Dr. Neal Smatresk, Dean of Science at the University of Texas at Arlington in preparation for testimony delivered to the Texas Higher Education Coordinating Board in 2000. See also J. Kayne, *op. cit.*

Employers as Primary Customers of Workforce Development Programs

Many recommendations in this report explicitly accentuate the importance of employers as customers of workforce development and technical education initiative such as Tech Prep and School-to-Careers as well as independent programs like High Schools that Work. (See, for example, G. Bottoms, et. al. *Making High Schools Work* Atlanta, GA: Southern Regional Education Board, 1992). This represents a significant shift in outlook from predecessor workforce development programs and from an “institution-centered” or “student-centered” approach to education and training. Prior to 1998, for example, federal workforce development focused primarily on the needs and wishes (how ever ill-informed) of service-eligible customers. Employers’ interests were represented through Private Industry Councils (PICs) and local vocational advisory boards. But all too often employer participation consisted of *pro forma,* after-the-fact approval of strategic plans developed rather independently by educators. Educators were held accountable merely to peer review and enrollment demands rather than to external standards related to post-exit employment or their respective communities’ economic development. All too often, educators and employers didn’t even “speak the same language.” (See Bristow and Anderberg, *Converging Paradigm* Austin, TX: SOICC, 1997.)

Workforce development programs in the past were targeted to the unemployed, economically disadvantaged and the low-skilled. Job placement consisted of appeals to employers’ charitable instincts or sense of civic duty. Appeals emphasized job-seekers’ prior employment problems rather than their knowledge, skills and abilities or potential productivity. Token employer participation predicated on sympathy or obligation was difficult to sustain. Employers often saw workforce development programs as a paperwork nightmare. They treated the nuisance of very limited involvement as a cost of doing business. They seldom made long-term investments in the participant’s ongoing skills upgrades or career advancement. Most participants were assigned low wage/low-skill jobs that lasted only so long as the employer received special tax credits or training assistance funds. Despite well-meaning but unenforceable rhetoric to the contrary, employers often perceived such funds as nothing more than short-term wage subsidies. (See R. McPherson, *Building a Local Workforce Services Delivery System* Austin, TX: TEC, 1997.)

The Workforce Investment Act of 1998 (WIA) mandates more pro-active involvement of employers in strategic planning to design service delivery on the front-end. That is reinforced by added emphasis on the back end through program evaluation based on measures of participants’ post-exit employment and earnings and of returns to the community-at-large for public investments in workforce development, education and training. (These same mandates appear in conforming amendments in the Perkins Act, the Wagner-Peyser Act and the Personal Responsibility and Work Opportunity Reconciliation Act.)

To some extent, Texas got a head start on WIA. Some PICs in Texas took employer participation requirements in the Job Training Partnership Act more seriously than others. Pro-active PICs gave primacy to employers in strategic planning and in validating demand-driven targeting of education and training services. (See Barnow and King, *Increasing the Odds*.) The successful best practices of the pro-active PICs paved the way for passage of state legislation in 1993 (Senate Bill 642) and 1995 (House Bill 1863) for demand-driven improvements in the Texas workforce development system.

Under the new model employers are treated as primary customers. They are engaged actively and early in the workforce development process. Education and training services are tied more directly to labor market demand. Thus, the likelihood is increased that program completers will find high-wage jobs with good prospects for employment retention and long-term economic security. But this only happens where local workforce development entities take on an identity that accentuates its commitment to employers as primary customers. (See McPherson, *op. cit.*)

III. Knowledge-Intensity at the Firm Level

Recommendations on the previous pages were directed primarily to stakeholders engaged in strategic planning and economic development. The recommendations were based on industry-level analysis. In the next section, we examine the impact of technology change at the firm level. At the end of this section, we offer additional recommendations for consideration by other sorts of stakeholders.

Firms within each sector are being sorted by level of technology-intensity.

All firms in the same industry don't embrace new technology with the same enthusiasm. We can sort firms on the six indicators listed previously in the section of this report on industry-level analysis. The most technology-intensive firms are apt to be those with:

- a capital-to-labor (K:L) ratio above the industry average;
- more significant investments in research and development;
- higher than the industry's average concentration of professional, managerial and technical workers (especially with postsecondary degrees in mathematics, science and engineering);
- shorter than average cycle for introducing new products or services (and its products and services have a shorter than average "half-life;"
- higher than average worker productivity; and
- a stronger than average orientation toward global competition.

> If a firm's stock is traded publicly, its technology-intensity may be deduced from information in its annual reports to stockholders. Such information probably isn't available for sole proprietorships and privately held firms.

Alternative indicators focus on changes in a firm's production techniques. How frequently does it retool its production line? How recently has it deployed new technology? Although critical to the assessment of technology-driven changes at the firm level, such information is considered proprietary by most firms — even those whose stock is traded publicly. This is precisely the sort of information that constitutes "local wisdom." Rather than looking to state and federal agencies to report on activities at the firm level, local decision-makers need to observe directly what businesses in their community are doing. They should solicit input locally from key business leaders, professional associations and organized labor.

See M. Anderberg, R. Campbell and N. Lewis, *The Infusion of Local Wisdom: Data Driven Planning at the Substate Level* (Austin, TX: Texas SOICC, 1999); R. Froeschle, *Economic Research and Employer Input* (Austin, TX: Texas SOICC, 1996); Haltiwanger and Jarmin, *op. cit.*

If the most preferred kind of firm-level data aren't available, local decision-makers must rely on inferences drawn from other characteristics. Proxy indicators to look for are the age of a firm; firm size; its organizational structure and its leadership/management style. Workforce investment boards, planners, one-stop operators and economic development officers can use these proxies in assessing changes in the technology-intensity of business establishments operating in their service area. Simple strategies of identifying and developing an action plan around each of these proxy indicators are offered below.

1. Look at how long a firm has been in business in order to form an educated guess about its likely response to new technology.

Small, young companies may have to take calculated risks in order to capture market shares from older competitors. More established firms have the luxury of taking a more conservative, risk-avoidance approach. Already having a foothold in the market, an older firm can take more time to weigh anticipated returns on investments in innovative technology more judiciously against the costs and risks. Years of practical experience have taught stalwart firms that "*innovation*" is not necessarily synonymous with "*effective*" or "*superior*."

1.1. Stalwart firms may take a wait-and-see posture. They can let newer companies experiment and innovate. Some high-risk taking competitors will fail because they sink too many dollars foolishly into new technology that does little to increase productivity. When the dust clears, an older and more established firm can buy up patents of risk-takers who succeed or buy out successful competitors' stock.

1.2. Older, more established firms may believe the prudent strategy is to wait until a new technology reaches its second or third generation. Any technology is likely to be cheaper and more effective as it matures.

> See J. Lerner, *Business, Innovation, and Public Policy in the Information Technology Industry* (unpublished paper from the Understanding the Digital Economy Conference, 1999) and D. Osborne, *op. cit*.

1.3. As new technology percolates through an industry, look for educational requirements and wages to increase first in younger companies. Later, better educated persons are apt to migrate to older companies. High-skill worker migration is likely to happen when start-up companies are absorbed by older and larger firms. That migration also can occur when older companies belatedly adopt new technology. In either case, stalwart firms simply up the ante to infuse their operations belatedly with "new blood" that can manage advancing technology.

1.4. To keep their competitive edge, older companies may troll the start-ups and raid their personnel. The stalwarts offer higher wages to recruit their successful competitors' best and brightest workers. The wage premiums are worth paying because, having already overseen the adoption of new technology in a start-up company, knowledge workers who migrate to the stalwart firms have the necessary experience to make a smoother transition the second time around.

What Does the Stock Market's Shake-Out of Technology Firms Tell Us?

Applying the label "*high technology*" to a firm, to an industry or to a marketing strategy doesn't guarantee its success. That is a lesson many are learning the hard way during the current stock market shake-out of technology firms. Only the strongest companies with **appropriately deployed** technology will survive.

Why is the stock market experiencing a shake-out? For a time, the high tech label seemed to promise extraordinarily high returns. The dawn of the New Millennium witnessed the birth of hundreds of high tech dot-com companies. Their birth announcements promised they would revolutionize the way we all do business. Venture capitalists, caught up in the euphoria over web-based marketing and the sizzle of electronic retailing, stumbled all over each other to fund every conceivable scheme. It takes fewer physical assets or professional certifications to start a dot-com company than it does to open a car repair shop. Every promising market segment — especially ones with highly visible examples of success like Netscape's initial public offering in 1995 — attracted lots of attention. Investors threw caution to the wind. Millions were paid just to acquire rights to catchy domain names.

As one venture capitalist put it, everyone caught "*dot-com fever*." In the frenzy, investors, afraid of losing the deal, funded too many "*first mover*" companies and paid too much to get them off the ground. Too many people with technical skills but little business savvy ran the start-ups. Companies with no *gravitas* went public before showing a profit — based on web design specifications rather than on a viable business plan. At the peak of the frenzy, business plans for dot-com start-ups amounted to a tentative site map and sample screens arrayed in a storyboard. At the same time, "*wanna-dots*" (organizations already well established in the off-line world) jumped on the dot-com bandwagon but went about it as if "*smearing lipstick on a bulldog*."

Investors bought icons, clicks, page views — but forgot the fact that you have to make money. At one point, "*irrational exuberance*" tempted some investors to abandon market fundamentals and disregard conventional measures of stock valuation. Some got so carried away that they advocated inventing new accounting methods to do away with such fundamental measures as price-to-earnings (P/E) ratio. The price of stock for start-ups with no earnings whatsoever skyrocketed on the assumptions that the market itself would judge the value of intangibles and "*money would continue chasing money*" indefinitely. Investors (especially inexperienced amateur day-traders) for-got the tried and true lessons of the past. First, it doesn't take much notoriety to transform one example of success (e.g., Netscape's gazelle-like take off n 1995) into a fad. Second, it only takes only one poorly managed company intent on buying market shares at any price to create a blood-bath in any category.

Now we read obituaries for firms once greeted in the market with such enthusiasm only two years earlier — even some that made their grand entry by advertising during the Superbowl. But their demise has many precedents. Excesses of the Roaring Twenties ended in the Great Crash of 1929. The booming 1960s petered out in the 1970s. A decade ago, several computer manufacturers and software publishing houses died because of market over-saturation. Many readers over thirty remember Osborne, Kaypro, Commodore, Northstar, Vector-Graphic, Eagle, Victor, Visi-Corp, WordStar, Priam, and Dysan — once highly touted companies that no longer exist.

As one MIT analysts put it, "*the simple truth is every new decade spawns only a handful of companies that deserve to be enduring members of NASDAQ. On the whole, companies that* *answer burning problems will quickly come to operate with high margins and start to generate cash — the mother's milk of all prosperity and the lubricant of growth. It is a pretty simple formula. Every time we tinker with the equation or delude ourselves to believe that tomorrow will be different, we get into trouble."* (M. Moritz, *Bigger Splash* in Technology Review, March, 2001 issue.) The current market shake-out reinforces this lesson for those in the Silicon Valley in California, around the IH-35 corridor in Texas, along Route 128 in New England and everywhere in between.

Some of the dot-com companies do meet the formula for success and will survive. Most likely, the survivors will be those that: engage in e-business (business-to-business or "*B2B*") rather than e-commerce (sales to retail customers); have a significant market presence in the off-line world **before** adding electronic marketing; use electronic marketing and order-taking to augment other forms of advertising and their bricks-and-mortar storefronts or warehouses (to become "*clicks and mortar*" or "*bricks and clicks*"); understand what customers genuinely want, maintain sufficient inventory to fill and efficiently delivery orders; and price their goods to make reasonable profits.

> In the first half of 2001, the website with the most new viewers were Walmart.com, JCPenny.com, BlueLight.com (K-Mart's website), and Target.com.
>
> E. Luening, *Big Brand Names Wooing Shoppers to the Web* at http://news.c-net.com (August 1, 2001)

Many more dot-coms, on the other hand, will not survive. They will likely find that no enterprise can endure if it:

- exists almost exclusively in cyberspace and relies primarily on the glitz of its technology or engages in nothing more than *cyber-squatting* (*domain-name profiteering*);
- charges for information content that customers can get for free elsewhere — particularly in an age when the Internet democratizes knowledge;
- tries to compete for vendors' advertising when it can't demonstrate that its website adds more value than a hundred other indistinguishable "*copy-dots*";
- sells everything as loss-leaders to establish a foothold in phantom (untested) markets; or
- stakes its reputation on its "*cash burn*" rate.

> The ability to **spend** money is not an indicator of the ability to **make** money.

The tech shake-out teaches another lesson as well. As a technology becomes more pervasive, it becomes susceptible to traditional business cycles. Before the knowledge economy emerged, industries were making capital investments in traditional plants, equipment and worker training. Technology expenditures constituted a small portion of most firms' budgets. But when new technologies began making significant impacts on various industries, firms began to engage in a virtual arms race. Every company wanted new technology that would allow them to better serve their customers' needs and make their manufacturing processes more efficient. The mind-set became one where companies that failed to lead their industries in technological deployment also failed to lead in the marketplace. Companies sought to implement latest state-of-the-art technology to hold on to market share. Thus, technology expenditures became a larger portion of company budgets in virtually every sector of the economy. IT spending, for example, rose from 15 percent of business equipment spending in 1960 to 25 percent in 1980. In 2000, the figure jumped to 53 percent.

The dramatic increase in IT spending in other industries made technology vendors susceptible to market forces that previously had no effect. When technology expenditures were a relatively small piece of overall budgets, firms bought information technology in boom times to outpace competitors. Hoping to prop up profits or to hold on to market share whenever the economy slowed, companies continued purchasing new technology even as they downsized. They justified these capital outlays by claiming that reduced labor costs offset their expenses. These days, technology procurement comprises a larger part of most every firm's budget. Analysts at Morgan Stanley concludes that as a result of this "*global corporate dependency on technology products,*" the information technology industry is "*now so large that it is no longer immune to standard business contractions associated with recessionary economies. . . Now that technology spending is such a large part of a company's overall budget, changes in the business cycle are likely to affect overall demand for technology products. Like it or not, [the once] high-flying [information] technology industry [must] be considered 'cyclical.'*"

Today, the information technology industry finds itself in a low point in the cycle. The frenzy has stopped. Firms across all industries are still buying new technology but at a slower pace. Industry-leading technology vendors such as Microsoft, Intel, Dell, Xerox and Cisco Systems find themselves with excess inventory. Their own overly optimistic sales and earnings forecasts simply extrapolated boom-time trends into the future on the naive assumption that the frenzy would last forever. It didn't. Their reports of less-than-expected earnings now hurt the price of their stock.

An overall economic slowdown began toward the end of 2000. Many economists and Wall Street analysts describe this as a rational market correction, not a full blown recession. Investors have stopped putting money into start-up Internet ventures that show no profits. Price-to-earnings and market-to-book value ratios are looking more realistic. Established firms are making more conservative estimates of anticipated sales and earnings. The shake-out's survivors can anticipate continued growth, albeit at a smaller but more sustainable rate.

Many analysts expect surviving technology stocks will rebound to lead an economic recovery in the next twelve to eighteen moths. Even as dot-coms that specialize in content and electronic retailing ("*e-tailing*") melt down, investors are jumping into other, more promising technology-driven industry segments: transactions-based B2B using XML (e**X**tensible **M**arkup **L**anguage), third generation (3G) wireless-enabled mobile commerce (m-commerce), optical networking, storage area networking, Internet infrastructure and back end functions (like web hosting services), enterprise resource management, residential broadband, etc.

To paraphrase Mark Twain, "*Reports about the death of the digital economy have been greatly exaggerated*." Appropriate new technologies still give businesses a competitive edge. Experts expect IT purchases to continue growing as a percent of business budgets. Firms that may have invested too much in new technology will refrain from ordering more automation tools **for**

awhile. But information technology — especially software — depreciates much more quickly than other capital equipment. Sales of IT should rebound when companies begin to replace equipment currently on hand. Corporate purchasing agents might be more cautious and skeptical about the promised benefits of next generation innovations. Technology vendors may have to continue discounting products **for awhile**. But, in keeping with Moore's Law, innovations will keep producing technology that is faster, smaller, more powerful and offers better resolution or more functional integration — at ever decreasing prices per unit. Companies that survive the slowdown will go through more rounds of technology change to keep pace with their remaining competitors.

Indeed, a survey of chief financial officers from major American corporations indicates that the vast majority expect to enter an expansive information technology procurement phase again by the end of 2002. Most CFOs fully expect the global IT market to double from $700 billion at present to $1.4 trillion by 2005 — an average annual growth rate fluctuating between 15 and 18 percent. Procurement priories will be driven by technology's impacts on productivity and customer relations management. While the first priority signals that technology will be purchased to improve back office operations and production control, the second priority suggests even electronic retailing, which is faltering most dramatically at present, also will rebound.

What do economists and stock market analysts expect?

Growth rates will be slower but sustainable as technology purchasing rebounds. After hovering above the long term trend line then falling below it, technology purchases will continue to increase across all industries. This increase, however, will be more consistent with the long-term trend line. The growth rate in IT purchases will remain above but roughly parallel to growth in the Gross National Product.

One or two firms will dominate each technology market segment. Historically in most every industry, 5 percent or fewer of the firms create 70 percent or more of the wealth. True to form, only 10 of the 400 Internet firms started since Netscape went public in 1995 are up 1,000 percent of their IPO price and only 22% are above their IPO price. Four percent of them have created 70 percent of the wealth. The losers go bankrupt and disappear as investors, no longer willing to throw good money after bad, stop bailing them out with massive infusions of cash. In each segment, the firm with the largest market share will continue to grow — especially through acquisitions of successful upstarts. Firms in second through fourth or fifth place (in terms of market shares in an industry segment) will likely negotiate mergers to compete more effectively with the industry segment's leading firm.

Industry leaders will continue searching for new markets in terms of new users or new uses — particularly migrating more of their corporate clients' functions to the Internet. IBM, for example, announced that it will spend a billion dollars to acquire Informix. Microsoft has embarked on a nationwide campaign touting enterprise solutions. In addition, industry leaders will continue pushing the envelope of technology transfer to make their products faster, smaller, more powerful, cheaper, more flexible and adaptable. Intel and Texas Instruments, for example, will produce semiconductors for a wider array of digital consumer products (microelectromechanical products or "*MEM*s") such as programmable refrigerators. Bayer is pushing the miniaturization and effectiveness of bedside devices to do diagnostics that once required sending samples to laboratories.

Across all industries, time-to-market acceleration will separate winners from losers.

Technology vendors will stop discounting their products and services once freed from a situation where too many competitors produced too much inventory. Profit margins will be healthy enough to sustain investor confidence. Industry leaders will continue doing the research and development necessary to keep ahead of the competition.

Investors will back start ups more selectively — scrutinizing their business models more carefully rather than being overawed by their technology schemes. Venture capitalists will take more time nurturing start-ups and wait until they show a profit before making an initial public offering of their stock. Disillusioned amateur day traders may stop playing the market while seasoned professionals go back to a strategy of buying and holding stock in the blue chip companies in each industry segment as longer term investments.

Meanwhile, the skills shortage in high tech occupations will continue. Experts see no significant influx of new tech workers on the horizon; instead, the current talent will realign. High skills workers given their pink slips by dot-coms will find work quickly in other industry segments that are hot or starting to heat up. These include: electronic security (encryption, intrusion-detection, firewalls; digital identity-verification); non-volatile random access memory; Internet infrastructure (e.g., web hosting, backbone traffic management and routing; optical carriers, storage area networking, more efficient bandwidth transport, voice-enabled access); XML-based B2B application development (supply chain integration/virtual company coordination, value-added commercial services; data warehousing/pooling, database mining, sales and marketing intelligence such as customer profiling, customer relations management, customer electronic self-service); lean manufacturing (just-in-time inventory control, build-to-order), residential broadband; wireless communications; biotechnology; and digital consumer applications (MEMs, appliances and household goods containing microchips for customer-programmable differentiation).

Highly skilled workers in technology-intensive occupations will still be in great demand inside and outside of the information technology industry. Look for them to be scattered across a wider variety of industries. Expect less variance across industries in the wages paid to any given high tech occupation. Stock option packages and inflated salaries typically offered by dot-com start-ups flush with venture capital will give way to compensation packages more in line with actual productivity.

As time-to-market of new products accelerates, the average tenure of high tech workers with specific firms will decrease. Highly skilled workers in technology-driven occupations will be more likely than ever to work on a project-to-project basis. They are more likely to find serial employment analogous to patterns in the construction trades.

As one consultant from the Silicon Valley puts it, "*I am like a contractor who builds houses. You don't build one house in 20 years. You keep going from house to house. Instead of building houses, I build applications.*"

These highly skilled workers are best advised to anticipate how the technology in their special field will change. They should use any downtime between projects to acquire next generation skills as necessary to enhance their long-term employment resilience.

For more in-depth analysis, see Arbortext, *XML for Managers* at http://www.arbortext.com/ think_tank; C. Barnes, et. al., *Dot-com Troubles Spin Revolving Door for Tech Workers* at http://news.cnet.com (November 2, 2000); T. Burton and B. Cohen, *When Can You Start? Building Better IT Skills and Careers* at http://www.itaa.org/workforce/ studies; R.M. Canter, *The Ten Deadly Mistakes of Wanna-Dots*, Harvard Business Review ((January 2001); CFO.com *It Spending Predicted to Double by 2005: Spending to Pick Up By Fourth Quarter* at http://cfomcom/ (May 3, 2001); L. Dignan, *Internet Security Firms Hanging Tough* at http://news.cnet.com/news (March 21, 2001); W. Gurley, *Good News Is the Bad News* at http://news.cnet.com/news (March 19, 2001); D. Henwood, *Blind Faith* Wired Archive (June 1998); S. Junnarkar, *Silver Lining in Layoffs* at http://news.cnet.com (November 2, 2000); M. Knaellos, *Intel Getting into Micro-Machines* at http://news.cnet.com/news on April 25, 2001; R. Konrad, *Tech Employees Jumping Jobs Faster* at http://news.cnet.com/news on June 14, 2000; M. Lagace, *Confessions of a Venture Capitalist* at http://hbsworking-knowledge.hbs.edu (February 12, 2001); Morgan Stanley Dean Witter, *The IT Crash: How Big? How Long?* (February 27, 2001), *Internet Ecosystem Basics* (March 10, 2001), *A Drill Down on the Internet User/Usage Ecosystem Framework* (March 27, 2001), and *Technology and the Economy: An Attempt at Pattern-Recognition* (April 5, 2001) all at http://www.morganstan-ley.com/techresearch/infohtml; A. Osterland. *Knowledge Capital Scorecard* at http://www.cfo.com (April 1, 2001); M. Tedeschi, *The WWW Land Rush* at http://www.bizforward.com (Feb., 2000); and all works by B. Lev cited in this report's bibliography.

2. Look for new technology to drive employment growth first in the smaller firms.

It's not smallness *per se* that drives a firm to be more innovative than other companies in the same industry. Small firms simply are less likely to be encumbered by multiple divisions, sunk costs and commitments to existing internal allocations of resources and power relationships. Thus, the odds are that there will be less internal resistance to innovation in a small firm. **Smallness does not guaranty inventiveness — it's just that smaller and younger businesses are the "most likely suspects" to look to for new job growth.**

A Study of the *"Job Generation Process"*

David Birch, an MIT economist, conducted a study using Dunn and Bradstreet data on 5.6 million American firms. Those firms represent 82 percent of private sec-tor employment. Birch and his colleagues concluded that 52 percent of all new jobs were created in independent firms with twenty or fewer employees. More than three-fourths of all new jobs were created by firms four years old or younger.

Most small firms, however, are irrelevant to innovation and growth. Birch's study concluded that most small firms "feed off growth rather than create it." Only a fraction of small companies have real growth potential. "About 10 percent of the small companies create 90 percent of the new jobs and don't stay small very long." The rest — the pizza parlors and shoe repair shops — are apt to putter along for years with the same small number of employees. They react to — rather than stimulate — economic activities in the enterprises around them.

The real lesson is that innovation — which often happens in young, growing firms — is the key to overall economic growth.

Birch is paraphrased seriatim by David Osbourne, *op. cit.*

2.1. The greater the number of positions potentially affected, the longer it will take a firm to react to and implement a new technology.

- A larger company will have to redefine more job descriptions, standard operating procedures, performance expectations and performance monitoring procedures in order to accommodate new technology.
- More incumbent workers will have to be retrained, replaced or terminated in a large firm.
- More resistance may be encountered in a large firm because of intra-divisional rival-ries over the distribution of resources, power and influence.

See E. Yourdon, *Decline and Fall of the American Programmer* (Engle-wood Cliffs, NJ: Prentice Hall, 1993)

FREQUENTLY CITED PREDICTION

The greatest need for Information Technology (IT) workers during the next decade will be in non-IT industries in companies with 50 to 100 employees.

Information Technology Association of America. *Bridging the Gap: Information Technology Skills for the New Millennium*. (Arlington, VA: Information Technology Association of America, 2000).

2.2. Another measure of firm size is the number of facilities it operates. The more facilities a firm operates, the longer it will take to implement a new technology. It simply requires more effort to coordinate activities among geographically scattered operations.

2.2(a). Look for technology change (and commensurate changes in educational requirements and wages) to occur first in mid-sized firms (50 to 500 employees and ten or fewer facilities). Large firms may be too cumbersome to implement a new technology quickly. On the other hand, the entire staff of a small firm (under 50) may be so totally absorbed in day to day production and marketing that they can't stay abreast of technical developments in their industry. Look for delayed diffusion of innovation from mid-sized firms in an industry to both larger and smaller firms.

See P. Drucker. *Innovation and Entrepreneurship: Practice and Principles*. (New York City, NY: Harper and Row, 1985); Lerner, *op. cit*.; and Acs and Audretsch *Innovation in Large and Small Firms: An Empirical Analysis* American Economic Review vol. 78 (1988); and D. Osbourne, *op. cit.*

2.2(b). Size *per se* does not deter large firms from embracing new technology. Look for larger firms to respond to pressure to innovate by creating spin-off units (so called "*skunk works*"). They may locate their spin-offs far from their main facilities. Off-site location can free upstarts within a firm (also known now as "*intraprises*") from the pressures of intra-organizational rivalries and iner-tia. If a spin-off operation proves successful, look for it to be the major source of new job creation within the parent company.

"Skunk Works"

Tracy Kidder, in his 1981 Pulitzer Prize winning book, *Soul of a New Machine*, referenced the term "skunk works." The term was used by Data General to describe its own spin-off operations. Later, the term was revived and popularized through Peters and Waterman's *In Search of Excellence.*

T. Kidder, *Soul of a New Machine* (New York City, NY: Modern Library, 1981);T. Peters and R. Waterman, *In Search of Excellence* (New York City, NY: Alfred Knopf, 1987); and D. Osbourne, *op. cit.*

3. Look at the management structure of a firm to determine its likely response to new technology.

New technology is more likely to be embraced first by a firm whose organizational structure is relatively flat. Because front-line workers are given more latitude and because they are not micro-managed in a flat organization, greater emphasis is placed on their critical thinking and problem-solving abilities. A firm with a flat organizational structure (also known as a *"high performance work organization"*) is more likely to recruit workers whose educational attainment exceeds the industry average. They tend to compensate their workers at a higher rate accordingly.

"Flat" Organizations

Rather than having multiple tiers of managers and supervisors arrayed hier-archically, a "*flat*" organization allows its front-line workers to handle multiple duties and tasks. Its workers are not assigned singular, repetitive tasks. Rather, work teams in a flat organization determine how their own duties and tasks will be organized, se-quenced and paced.

See Tom Peters. *Thriving on Chaos*. (New York City, NY: Alfred Knopf, 1987); as well as Hitt and Byrnolfsson, *Information Technology and Internal Firm Organization: An Exploratory Analysis* in Journal of Management Information Systems Vol. 42, no. 2 (1997).

Given the importance of small firm innovation, regional policy-makers could benefit greatly by having such innovators represented in the public workforce development system.

Recommendation #3: In building workforce development partnerships, aggressively recruit representatives of local industries that are moving most rapidly up the scales of technology- and knowledge-intensity.

Local councils and advisory boards have wide latitude for setting policy and planning strategically for the delivery of education, training, workforce development and welfare-to-work assistance. State and federal legislation mandates that private for-profit firms play a prominent role on such councils and advisory boards. However, state and federal rules don't stipulate what kinds of private sector firms should be represented.

Older, labor-intensive manufacturing or resource-intensive extractive industries may well have been the foundation of a community's economic base for decades. Every time a new governance arrangement stipulates that local businesses should be represented, representatives of the well established firms are the first to be summoned. They are accustomed to playing a dominant role in local decision-making circles. Communities traditionally defer to their wisdom and honor their wishes. That kind of traditional deference is understandable. Leaders of an area's well-established industries have a deep sense of civic duty. Most are willing when called to serve. The community owes then a deep debt of gratitude for their past contributions.

Leaders of established industries may be relatively content with the output of the education and training pipeline. Because stalwart industries perennially have had a huge say in shaping the curriculum, it probably meets their needs. Indeed, the current curriculum conceivably could continue to meet the needs of well established industries for the foreseeable future with only incremental changes. KSA requirements for employment in larger, more established firms on the low end of the technology-intensity spectrum are likely to change slowly — that is, relative to the pace of change experienced by their technology- and knowledge-intensive neighbors.

The complacency of stalwart firms is misplaced if they aren't fully informed about the needs of newer, more rapidly changing business establishments in their community. Representatives of technology-intensive industries **currently** driving local economic growth must have a major role in local decision-making. Without them, advisory boards — despite meeting *pro forma* private sector composition requirements — may be more inclined to persist in an outmoded "cheap labor" approach to economic development. Input from its most technology-intensive firms is essential if a community is to address the education and training requirements of a knowledge-based economy.

Representatives of technology-intensive industries must sit on local workforce investment Boards to provide input on their rapidly changing KSA requirements. Otherwise, local employers with the most growth potential will perceive one-stop workforce centers as merely tinkering at the margins.

- If local workforce investment boards, planners, case managers, counselors and job developers don't pay close enough attention to rapidly changing KSA requirements of jobs in dynamic, technology-driven firms, employers with great growth potential will be reluctant to post their managerial, professional or technical openings with the Employment Service (ES) job bank. They will continue to think of the ES as they did in the years before the WIA — namely, as a labor exchange function oper-ating at the low-skill, low-wage end of employment supply and demand. Employers who hold these beliefs also will be reluctant to consider job applicants referred to them by their local one-stop workforce center for anything other than day labor and the low-skill, low-wage jobs.
- If they don't see the ES addressing KSA needs in the upper strata of their staffing patterns, technology-driven firms will have little reason to turn to the one-stop work-force centers for any other employer services. If they aren't satisfied with the basic Employer Service, why should technology-driven firms turn to the local workforce center for auxiliary services? Employers who hold these beliefs aren't likely to open OJT slots for workforce development and welfare-to-work program participants.

If technology-intensive firms aren't well represented on local vocational advisory boards, regional Tech Prep consortia and School-to-Career partnerships, then the local secondary and postsecondary technical education curriculum may be perpetually outdated. The curriculum must be revised and adapted quickly enough to meet changing KSA requirements — especially in the very industries that are driving the community's economic growth.

If they believe the curriculum isn't updated quickly enough to address rapidly changing KSA requirements of technology-impacted jobs, employers with the most growth potential will be reluctant to hire local program graduates.

- Employers may overlook qualified local program graduates if they presume that education and training providers in other communities are more responsive to demands for updated, technology-driven KSAs in the curriculum. They also may resort to hiring certified alien workers with H1-B visas.
- Such employers may feel they have no choice but to relocate operations offshore or in another community where they believe their ever changing needs for technology-savvy workers will be addressed more promptly.

On the other hand, employers who feel they had a voice in shaping the curriculum are more likely to volunteer their time to provide auxiliary learning opportunities such as mentoring, shadowing, internships, summer work opportunities or apprenticeships.

Recommendation #3(a): When forming workforce development partnerships, don't overlook the smaller and younger firms in the community — especially those whose organizational structures are relatively flat. They are the "most likely suspects" to be moving up the scales of knowledge- and technology-intensity (regardless of industry sector). Their needs are more likely to constitute the leading edge of curriculum revision.

We strongly recommend that smaller and younger firms be represented adequately on local workforce investment boards, Tech Prep and School-to-Career consortia and local vocational advisory boards. However, from the local control perspective, any rule issued by the State mandating representation by size category might be too inflexible and would encroach on local decision-makers' prerogatives. Without infringing on local control, state level program representatives and liaison could give technical assistance to help local boards and consortia identify prospective partners. That would go a long way toward ensuring that the needs and demands of small and young (but technology-intensive) firms are given sufficient consideration.

Recommendation #3(b): Use resources provided by the Career Development Resources and Labor Market Information units of the Texas Workforce Commission to identify prospective partners and facilitate contact with their chief executives or human resource officers.

The Career Development Resources (CDR) and Labor Market Information (LMI) units of the Texas Workforce Commission (TWC) supply local workforce investment boards with annually updated employer contact information databases. Local boards, consortia and partnerships can use the databases when trying to recruit representatives from local firms in technology- and knowledge-intensive industries. The LMI-provided database can be sorted by SIC, zip code and firm size. The employer contact database is available on-line through the TRACER labor market information software located on the TWC webpage. An additional source of employer contact information is made available by the CDR through SOCRATES, regional planning software for registered users in Texas (http://socrates.cdr.state.tx.us).

IV. High Technology and Occupational Classifications

Earlier in this report we used Canada's "*technology-intensity*" construct to identify which industries and which firms within each sector are likely places to look for employment demand growth — especially for jobs that will pay high wages and which offer above average prospects for employment resiliency. At the industry level and at the firm level, however, discussions of *technology-intensity*" are grossly oversimplified. Strictly speaking, it is not appropriate to describe any industry as "*high tech*." The products or services of an industry may involve new technologies; however, workers in many of the jobs — even in the industries that produce and service the newest business machines and consumer electronics — seldom use those technologies. **Strictly speaking, *"high technology*" is an attribute of some occupations, not of whole industries or of specific firms.**

"*Low Tech*" Occupational Demand in a "*High Tech*" Industry

On September 25, 2000, an announcer on 102.3FM radio in Austin, Texas inquired: "Are you tired of stocking shelves at a grocery store at 3:00AM? Do you have experience sorting mail at the Post Office?"

Those are the opening lines of a commercial inviting job-seekers to a job fair being conducting on behalf of Applied Materials. Applied Materials is one of the nation's leading firms in developing machines to produce and do laser etching of semiconductors. By all the criteria listed previously, Applied Materials would be classified as a "*high technology*" firm. Nonetheless, it subcontracts with a temporary help agency (West Valley Staffing) to hire inventory-order clerk, forklift operator, warehouse laborer, and packaging and shipping clerk positions.

Clerks and warehouse workers hired through the job fair initially will be em-ployees of West Valley Staffing. Therefore, they will be classified officially as working in the Help Supply/Personnel Services Industry. The Standard Industry Classification (SIC) for the temporary help agency is 7363. Nonetheless, such *"low tech*" workers will be integral to operations at Applied Materials (SIC = 3359). So, to some extent, the use of less skilled workers in high tech industries is masked by outsourcing low end positions through temp agencies.

See R. Froeschle, et. al., *The "Contract and Flexible" Workforce* (Austin, TX: SOICC, 1997).

The anecdotal illustration from Applied Materials is not an isolated, atypical example. Look again at Table I on page 15. All of the ten most technology-intensive industries in the Canadian study had less than 20 percent of their personnel devoted to research and development. Of the four Canadian industries which most closely parallel what Americans commonly call *"information technology*" (Communications and Other Electronics, Computers and Related Services, Business Machines and Other Electrical and Electronics Manufacturing), only one had more than two-thirds of its staffing pattern comprised of persons with some postsecondary credential. That was the Computers and Related Services Industry at 69.2 percent. Of those four industry sectors in Canada, Computers and Related Services led the way with 42 percent of its staffing pattern comprised of engineers and scientists. Engineers and scientists comprised less than one-fourth of the staffing patterns among the other three Canadian industries involved deeply in information technology. The balance of employees in those "*high tech*" industries are janitors, warehouse workers, receptionists, general filing clerks, cafeteria workers, and groundskeepers, etc.

On the other hand, virtually every industry will have some high tech occupations in its common staffing pattern. Jobs requiring mastery of some sort of digital technology are even scattered across industries considered by the press and popular opinion to be at the low end of the technology-intensity scale. Look again at the predictions in the text box on page 46 or consider the following examples.

- The H.E.Butt Company (HEB, one of Texas's largest Retail Grocery chains) constantly looks for systems analysts, programmers and computer technicians to work at its home office in San Antonio. Although the Retail Grocery industry generally is considered to be at the lower end of the technology spectrum, HEB relies on digital technologies to poll sales figures from each store. Sales detail are monitored by just-in-time inventory control programs to meet customer demands promptly while reducing shrinkage of perishable items and optimizing cash flow.

- The staffing pattern for a typical Residential Construction firm consists mostly of carpenters, plumbers, roofers, concrete workers, truck drivers, electricians and laborers. Nonetheless, most Residential Construction firms' books and accounts are automated. They use soft-ware like MicroSoft Project Manager to ensure that materials and personnel are sent to the right sites in proper sequence. Residential Construction firms are linked electronically to Lumber Yards, Plumbing Fixture and Supply Wholesalers, etc. that can do take-offs (mater-ial ordering and delivery sequencing) directly from digitized blueprints and specifications. Residential Construction offices are linked electronically to financial institutions to improve cash flow through real-time (on-line) draws against home buyers' interim construction loans.

These examples illustrate two essential points. First, "*high tech*," strictly speaking is an **occupational** characteristic. Second, although concentrated more heavily in some industries than in others, high tech occupations are scattered across all industries. Therefore, local workforce investment boards must do very detailed labor market analysis. **To be effective, services must be targeted to specific occupations.** Industry-level analysis won't suffice for career guidance, case management and job development. Nor will industry-level analysis suffice for collaboration with education and training providers. More detailed occupational analysis is required to ensure that the curriculum remains responsive to the demands of a knowledge-based economy.

Another point must be kept in mind. Namely, most jobs in the coming decade will require low to moderate skills. Indeed, fourteen of the twenty occupations atop the Texas list for projected openings to the year 2008 require only short-term or moderate-term on-the-job training (OJT). In descending order of projected openings, they are: Cashiers, Retail Salespersons, Fast Food Preparation Workers, Waiters and Waitresses, General Office Clerks, Food Preparation Workers, Heavy Truck Drivers, Janitors and Cleaners, Security Guards, Telemarketers, Information Clerks, Manufacturing Sales Representatives, Landscaping Laborers, and Nursing Aides/Orderlies.

For Texas projections to the year 2008 with prevailing wages and recommended education and training requirements, go to the website for the Labor Market Information Department of the Texas Workforce Commission at http://www.twc.state.tx.us/lmi/. For national projections go to the websites for the Department of Labor: Bureau of Labor Statistics (BLS) at http://www.bls.gov or the Employment and Training Administration (ETA) website at http://www.doleta.gov.

Low-Skill Jobs Are Not Going Away Any Time Soon

Occupations with the largest predicted numerical increases nationally are cashiers, janitors, retail salespersons, waiters and waitresses. Together, they are expected to account for thirteen percent of all new job growth. Fully forty percent of the jobs of the coming decade will be low-skill. Low- and medium-skilled occupations combined will account for seventy percent of all jobs.

See *The New Economy: High-Wage, High-Skill Jobs Have Grown, But So Have Low-Wage Low-Skill Jobs* at http://neweconomyindex.org/section1-page02.html (Washington, DC: Progressive Policy Institute, 2000)

If low- to moderate-skill occupations dominate the list of projected job openings in Texas and across the nation, why focus on high-skill occupations? There are several answers.

1) High-skill occupations tend to have the highest **rates** of new demand growth. While there is a general shortage of workers in all occupational fields in any booming economy, the curriculum already turns out workers capable of handling most low- to moderate-skill jobs. Because the KSA requirements of low-skill jobs change more slowly, less effort is required to keep the curriculum responsive on the low end of the employment spectrum. Even when the curriculum doesn't formally address low-skill occupations, job-seekers usually can do entry-level work after seeing a simple demonstration or after receiving on-the-job training that lasts no more than a few hours or days. High-end jobs, on the other hand, are harder to fill. **When employers complain about the inadequate supply of appropriately trained job applicants, they most frequently are talking in terms of openings at the top end of their staffing patterns: managerial, professional and technical positions.**

2) Addressing employment demands at the higher end of local firms' staffing patterns is mission-critical to Texas's overall workforce development strategy. A shared (core) objective of education and training programs, workforce preparation initiatives and welfare-to-work reforms is to help individuals achieve financial self-sufficiency and economic security. Programs must focus on jobs that pay well and afford the best long-term employment prospects if they are to meet their performance measures. Those kinds of jobs require higher skill levels. Students and program participants need to be informed fully about the fundamental connections among high skills, higher pay and long-term employment resiliency.

3) Most important, the consequences of failing to address the KSA needs at the high-skill end of the spectrum are more drastic. When there is a skills gap at the higher end of the spectrum, our economy loses momentum. Businesses are less likely to achieve maximum productivity and profitability. They may forego critical economic activities and miss opportunities for growth if they can't find appropriately skilled workers for their high tech positions. Without constantly improving productivity and growth — especially at the high end — the economy loses its edge in global competition. Where that happens, communities are less likely to prosper. Texas residents will have fewer employment options that provide genuine economic security at all stages of the education and training system.

Each of these points is addressed in more detail below.

The Rate of New Job Growth is Faster in High-Skill Occupations.

The **absolute** numbers tell us there will be more job openings in the low- to moderate-skill occupations. However, most of the demand at the low end of the skills spectrum will be for replacement workers. **The rate of new job growth is highest in fields which are above average in their use of technology.** Persons seeking these jobs require more education and training. Table IV highlights some of the occupations with the highest projected **rates** of new job creation.

Job developers, case managers and counselors should pay particular attention to the fastest growing occupations. In doing so, they will improve services to both employers and program participants. Even if the job-placement numbers are small in the beginning, local employers appreciate help in filling their fast growing, high-skill vacancies. By serving employers' high-end needs, work-force centers can enhance their credibility in the eyes of the business community. Such a focus can prime the pump to persuade fast growing firms to post all of their job openings with the ES. Then, having gained more respect for the ES, those employers will be more likely to offer OJT opportu-nities for carefully screened program participants through the one-stop workforce centers.

The Connection Between High Skill Education and Training and Economic Security.

At the core of our economic system are the simple laws of supply and demand. At present, demand for high-skill workers exceeds supply. Wage premiums must be offered to recruit and retain workers who have the KSAs to handle the high technology portions of an industry's production or a business's services. (See Tables V and VI for concrete illustrations of the relationship of education and training to earnings prospects.) Information about the connection from education and training to high wages is vitally important in career development. Counselors can use such information to encourage students and adult learners to persist to program completion. The data almost invariably make a persuasive case for persistence by showing that the long-term returns to education and training in technical fields exceed short-term opportunity costs.

Table IV

Projected Job Growth in Select High-Technology Occupations

	Projected Rate of Change to 2008	
Occupational Title	Texas	U.S.
Computer Engineers	48.1%	107.9%
Computer Support Specialists	67.8%	102.3%
Computer Systems Analysts	66.9%	93.6%
Database Administrators	48.3%	77.2%
Desktop Publishing Specialists	95.1%	72.6%
Data Processing Equipment Repairers	14.4%	47.0%
Electronic Semiconductor Processors	33.0%	45.2%
Engineering and Computer Systems Managers	38.6%	43.5%
Average projected growth for all occupations	17.4%	14.4%

Source: U.S. Department of Labor, *Occupational Outlook Handbook — 2008 Projections* and *Texas Workforce Commission,* Labor Market Information Projections 1998-2008.

Workforce investment boards, workforce center staff, Tech Prep consortia and regional School-to-Career partnerships all need to keep their fingers on the pulse of the fastest growing occupations. Local officials should validate the rates of occupational employment growth for their unique labor markets. They can start by reviewing projections at the workforce investment board level. Regional projections are provided by the Labor Market Information (LMI) unit of the TWC.) The LMI's regional projections should be refined using local wisdom. Lastly, the logic used by the board and strategic planners in targeting occupationally-oriented service delivery must be explained carefully to front-line staff in the workforce centers. It is especially important that case managers and counselors who are in direct contact with program participants have a thorough understanding of occupational employment trends. That level of understanding is essential to sound advising.

See Anderberg, et. al., *op. cit*.; Richard Froeschle, *Connecting the Dots: Essays for the Practitioner* (Austin, TX: Texas SOICC, 2000); and Froeschle, Anderberg and Dimmit, *Using Career Information in an Applied Case Management or Counseling Setting* (Austin, TX: Texas SOICC, 1998).

Table V

Projected Employment Demand and Earnings by Level of Education and Training in Texas

Level of education and training required	1998 Employment	% of 1998 Employment	Projected Employment in 2008	% Change in Employment 1998 to 2008	Total Avg. Annual Openings	% of Total Avg. Annual Openings	Average Wage in 1998
Short-term on-the-job training (OJT)	3,440,107	34.96	4,036,111	17.33	163,539	40.45	$ 8.26
Moderate on-the-job training (OJT)	1,659,583	16.86	1,885,123	13.59	57,381	14.19	$ 11.51
Long-term on-the-job training	1,018,503	10.35	1,200,535	17.87	40,792	10.10	$ 12.12
Work Experience	660,752	6.71	766,176	15.96	24,464	6.05	$ 15.85
Some postsecondary vocational training	359,470	3.65	406,897	13.19	12,603	3.12	$ 13.30
Associate Degree	342,586	3.48	439,141	28.18	15,862	3.92	$ 17.72
Bachelor's Degree	1,266,414	12.87	1,523,934	20.33	52,062	12.88	$ 19.74
Bachelor's plus Work Experience	763,217	7.75	907,941	18.96	27,525	6.81	$ 23.24
Master's Degree	107,008	1.09	133,372	24.96	4,593	1.14	$ 18.75
Ph.D.	28,458	.29	35,869	26.04	1,509	.37	$ 25.77
1st Professional Degree	134,302	1.36	151,150	12.54	3,928	.97	$ 35.94
Total	**9,780,400**	**100.00**	**11,486,598**	**17.44**	**404,258**	**100.00**	**$ 13.40**

Source: Texas Workforce Commission Labor Market Information unit projections with analysis of training requirements by the CDR. Occupations included in this analysis represent 99.4 percent of the TWC/LMI projected total.

Table VI

Projected Nationwide Growth and Earnings for Select Occupations

Occupations (grouped by education and training required)	Projected 1998-2008 Growth	Projected Growth Rate	Earnings Quartile
Post-Baccalaureate Degree			
Operations Research	7,000	9%	Top
Bachelor's Degree			
Systems Analyst	577,000	94%	Top
Computer Engineer	323,000	108%	Top
Computer Programmer	191,000	30%	Top
Computer System Manager	142,000	43%	Top
Electrical/Electronic Engineer	93,000	26%	Top
Graphics Designers	91,000	27%	Third
Associate's Degree			
Computer Support Specialist	439,000	102%	Top
Electronic Technician	56,000	17%	Top
Health Information Technician	41,000	44%	Second
DP Equipment Repairer	37,000	47%	Third
Short to Moderate On the Job Training (OJT)	563,000	14%	Bottom
Retail Salesperson	556,000	17%	Bottom
Cashiers	493,000	17%	Third
Truck Drivers	463,000	15%	Bottom
General Office Clerks	433,000	58%	Bottom
Home Health Aides	365,000	11%	Bottom
Janitors and Cleaners	325,000	24%	Bottom
Nursing Aides	305,000	25%	Second
Receptionists	303,000	15%	Bottom
Waiters and Waitresses	294,000	29%	Bottom
Security Guards	247,000	12%	Bottom
Food Counter Clerks	234,000	21%	Bottom

Source: *Occupational Outlook Quarterly,* Winter 1999-2000

The bottom line from the workforce development program participant's perspective is that high-skill jobs are the ones that lead to economic security and financial self-sufficiency

- **if** they have the required aptitudes and interests, and
- **if** they get appropriate education and training.

Students may need professional guidance as they exit the education and training pipeline to begin searching for work. All too often, program exiters restrict their own horizons. They miss viable options if they focus their job search only on one or two dominant industries related to their field of study. A graduate of a Computer Science program, for example, might look only at Software Development companies and Computer Hardware Manufacturing firms. In doing so, that student would miss lucrative prospects in other industries — as in the Grocery Store and Residential Construction illustrations given previously.

The Debate Over "Between-Industry" and "Within-Industry" Factors in Explaining the Wage Premium Paid to More Educated Workers

On first blush, the evidence suggests that skills-based technology change is responsible for the dramatic increase in the earnings of more educated workers relative to less educated workers. The wage premium associated with technological change is primarily due to the sorting of better workers into those industries. Wages tend to be higher in industries subject to rapid technology change. Thus, conventional wisdom focuses on between-industry differences in technology implementation.

> See, for example, Ann P. Bartel and Nachum Sicherman, *Technology Change and Wages: An Inter-Industry Analysis* National Bureau of Economic Research (February 1997).

On the other hand, some economists are beginning to realize that within-industry changes in skill-utilization are driving the demand for and wage premiums paid to more educated workers. The most significant sorting of workers economically is going on **within** industries. The best and the brightest workers are going into technology-driven **occupations.** They are the ones who will enjoy the best prospects for long-term economic security.

> Paraphrased from Autor, Katz and Krueger, *Computing Inequality: Have Computers Changed the Labor Market?* National Bureau of Economic Research working paper # W5956 (March 1997)

What Are the "*High Tech*" Occupations?

Sorting of workers at the firm level into high-tech and low-tech occupations is a key determinant of their future economic security. Because this sorting has such important, lifelong consequences for all workers, the concept of "*high tech*" — **as it applies to occupations** — needs to be explored in greater detail. To make truly informed career choices, students and workforce development program participants need to know more precisely what it will take to succeed in high tech occupations. Unfortunately, most readily available information about the labor market focuses on industry level activities. By and large, newspaper and television coverage is anecdotal. Coverage often is superficial and sprinkled with buzz words used imprecisely. Most academic research is more precise and data-driven but currently it, too, is done at the industry level. Most government initiatives are targeted at the industry level as well. But an industry oriented approach is too shallow and oversimplified to be an effective guide to strategic planning or individual career development.

One recent empirical study stands head and shoulders above the rest, *The Supply of Information Technology Workers in the United States* (Washington, DC: Computer Research Association, 1999). The research was done by William Aspray and Peter Freeman under a grant from the National Science Foundation. Aspray and Freeman shake free from the conventional, industry oriented definitions of "*high tech.*" The authors look beyond industries which produce computers and software, telecommunications and business equipment. Aspray and Freeman show how information technology touches almost every occupational field— some more, some less. Thus, they avoid conceptualizing "*high technology*" as a dichotomous (either-or) variable.

Instead of taking a conventional approach, Aspray and Freeman suggest a useful new framework for mapping the job requirements of many common occupations. They don't go overboard in presuming that the tools of a trade are the only consideration in mapping job requirements. Their approach balances technology considerations against other factors that need to be taken into account in career guidance and in curriculum development. This balance in their approach is Aspray and Freeman's most valuable contribution to the ongoing discussion of high tech occupational supply and demand.

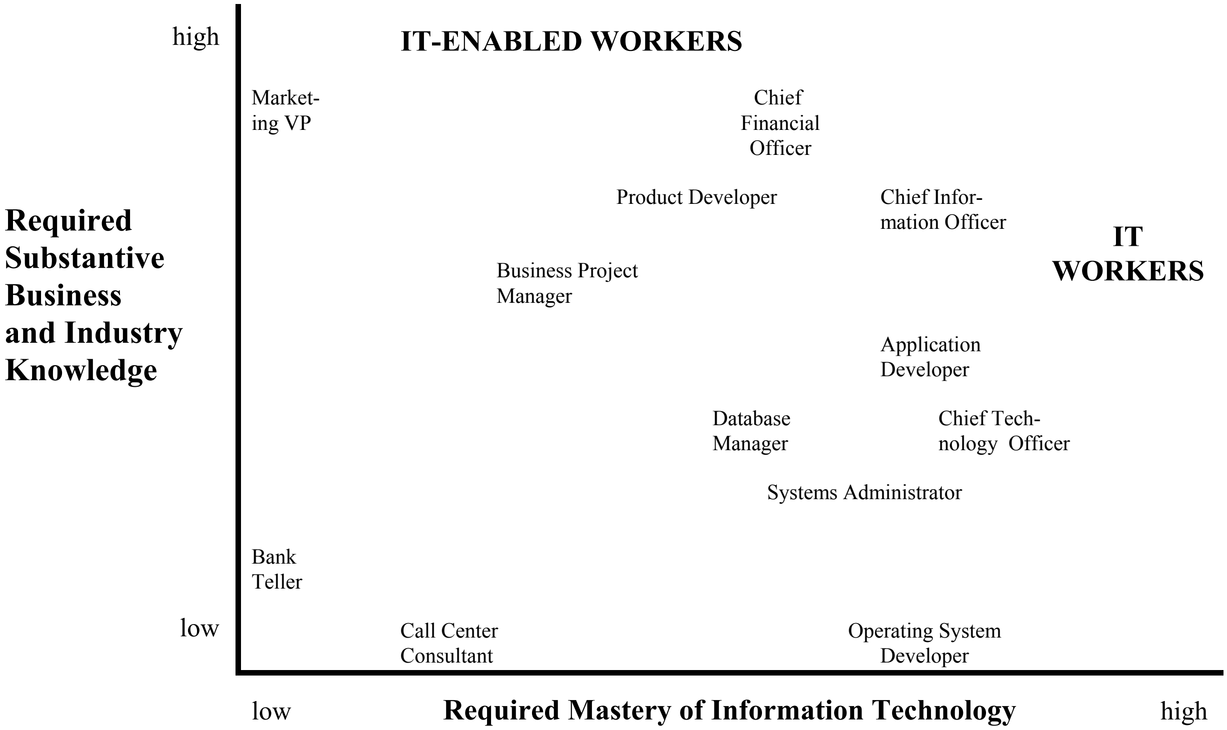
According to Aspray and Freeman, any occupation requires a blend of knowledge about both information technology and substantive industry knowledge. Both dimensions are sliding scales. Figure 1 on the next page depicts how specific occupations are arrayed on those two dimensions. Both aspects must be understood fully if the curriculum is to address the appropriate balance of technology training and substantive business knowledge in each occupational field.

To be effective, decision-makers in charge of guidance and curriculum development must consider relationships between the duties and tasks in each occupation and information technology. Those relationships are complex. Aspray and Freeman offer additional insights to help stakeholders understand those relationships. They use a taxonomy established by Computing Research Associates (CRA) to identify four different kinds of occupation-to-IT relationships:

- ***Conceptualizers*** conceive of and sketch out the basic nature of computer systems.
- ***Developers*** specify, design, construct and test information technologies.
- ***Extenders/Modifiers*** modify or add information to the systems.
- ***Supporters/Tenders*** deliver, install operate, maintain or repair information technologies.

The classification of specific occupations (Figure 2) shows how the CRA's taxonomy is useful in differentiating occupations which all too commonly are lumped together in less sophisticated analysis.

Figure 1: Occupational Employment Requirements as a Mix of Business and Industry Knowledge and Information Technology (IT)



Adapted from Figure 2-2 in Aspray and Freeman, page 32.

Figure 2: Illustrations of the Computing Research Associates's Taxonomy for IT Occupations

Conceptualizers
- Entrepreneur
- Product Developer
- Research Engineer
- Systems Analyst
- Computer Science Engineer
- System Architect

Modifiers/Extenders
- Maintenance Programmer
- Programmer
- Software Engineer
- Database Manager
- Network Administrator

Developers
- System Designer
- Programmer
- Software Engineer
- Tester
- Computer Engineer
- Microprocessor Designer
- Chip Designer

Supporters/Tenders
- Systems Sales Consultant
- Customer Support Desk Specialist
- Hardware maintenance Specialist
- Network Installer
- Fiber Optics Cable Installer

Adapted from Table 2-2 in Aspray and Freeman, page 33

Using the CRA's taxonomy, Aspray and Freeman tie groups of technology-impacted occupations to levels of education and training in a very broad sense. Table VII rates the likelihood of each educational category as the terminal exit point for each occupation-to-IT cluster.

Table VII

Typical Educational Preparation Level for IT Job Clusters

CRA's Occupation-to-Technology Taxonomy	High School	Associate Degree	Bachelor's Degree	Master's Degree	Doctorate
Conceptualizer	occasional	occasional	common	frequent	frequent
Developer	unlikely	unlikely	common	common	occasional
Modifier/Extender	unlikely	occasional	common	common	occasional
Supporter/Tender	occasional	frequent	common	unlikely	unlikely

Adapted from Aspray and Freeman, Figure 2-3, page 34.

Next, Aspray and Freeman address the need to balance the curriculum according to the relationship between occupational employment and the use of information technology. Table VIII suggests what mix of training and preparation is appropriate for each grouping of IT workers.

Table VIII

Typical Curriculum Emphasis for IT Job Clusters

CRA's Occupation-to-Technology Taxonomy	Training in Information Technology	Knowledge of Business and Industry	Training in Communications and Organization
Conceptualizer	4	2	1
Developer	3	2	3
Modifier/Extender	2	3	3
Supporter/Tender	1	2	3
Scale: 1-least important; 2-moderately important; 3-important; 4-critically important			

Adapted from Aspray and Freeman, Table 2-6, page 39.

Last, Aspray and Freeman offer their observations about the education and training pipeline to high technology jobs. It is their impression, based on the input of employers and educators, that appropriate courses are available to interested students. Courses in each technical field are arrayed in sequence to build competencies required in the most technology-intensive occupations. Indeed, advanced degree programs in technical fields at American postsecondary institutions enjoy world class reputations. Nonetheless, Aspray and Freeman see three main obstacles in meeting demands for appropriately skilled workers.

1) The technologies are changing so rapidly that even world class postsecondary institutions have problems keeping the curriculum current. All too often colleges and universities are constrained by slow moving processes for new program approval and funding.

> From personal correspondence with and public testimony of Dr. Neal Smatresk, Dean of Science at the University of Texas at Arlington. See also Mears and Sargent, *The Digital Workforce: Building Infotech Skills at the Speed of Innovation* (Washington DC: U.S. Department of Commerce, 1999).

2) Too few students are entering the pipeline. At a time when employment demand is growing, enrollments are declining nationwide in critical fields like mathematics, science and engineering. Females and minority students in particular are grossly underrepresented in disciplines critically important to economic growth and global competitiveness.

> In addition to Aspray and Freeman, see American Association for the Advancement of Science, *Losing Ground: Science and Engineering Graduate Education of Black and Hispanic Americans* (Washington, DC: AAAS, 1998); Aspray, W. and A. Bernet**,** *Recruitment and Retention of Underrepresented Minority Graduate Students in Computer Science* (Washington, DC: Computer Research Association, 2000); Carmel, et. al. *The Digital Economy Factbook* (Washington, DC: The Progress and Freedom Foundation, 1999); Cartright and Skinner, *Higher Education and the Technology Workforce Shortage* Change, May-June, 1998; Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development (a.k.a. Morella Commission) *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology* (Washington, DC: National Science Foundation, 2000); J. Galvin, *Education's Response to the Information Technology Worker Shortage* (Newton, MA: Education Development Center, Inc., 1999); National Science Foundation, *Science and Engineering Degrees by Race/ Ethnicity of Recipients: 1989-1996* (Arlington, VA: NSF, 1999); Office of Technology Policy, *America's New Deficit: The Shortage of Information Technology Workers* (Washington DC: U.S. Department of Commerce, 1997); THECB Task Force on Development of the Technology Workforce, *op. cit*.

3) The education and training pipeline for IT-driven occupations is more like a funnel made from a porous, sieve-like material than a continuous flow channel. Too few of the students interested in mathematics, science and technology graduate with postsecondary degrees in those disciplines. Many arrive on campus ill-prepared to do college level work in rigorous subjects. They may turn to other majors rather than take remedial courses. Many don't make it through the gatekeeping courses. Many who do make it through the gateway courses burn out or lose interest and change majors if they are overwhelmed by upper division courses that are far more difficult. Others exit for financial reasons before achieving their educational objectives.

Educational Opportunities in Mathematics, Science and Technology Are Expanding But Gatekeeping and Fallout Can Leave the Cupboard Bare

Admissions requirements have been relaxed at many postsecondary institutions. This should give more students an opportunity to take the math, science or technical courses they need for high tech careers. However, lower admission standards raise concerns among educators about preserving academic rigor in their disciplines. To keep from watering down upper division courses, they use introductory courses at the freshman and sophomore level as "*gateways*." (That is, successful completion of a core introductory course often is a prerequisite for taking any upper division courses in the discipline.) One public postsecondary institution in Texas reported its annual failure rate in Introduction to Physics, for example, consistently hovers around 57 percent.

Other task group members reported slightly lower failing rates in the freshman math and science courses at their institutions. However, where the freshman "filters" are not stringent, "*wash out*" rates in upper division courses are higher. Regardless of where the fall out occurs, the consensus among task group members is that fewer than 10 percent of the incoming freshmen who declare an intent to major in mathematics, science or engineering persist to obtain a bachelor's degree in one of those fields.

See the Minutes of the Texas University School-to-Careers Task Group, October, 2000.

4) The education and training pipeline itself is weakened by the absence of qualified instructors. The best and the brightest math, science and engineering students aspire to and get hired in the private sector or in a prestigious research university where the pay is much better. Aspray and Freeman discuss this "*seed corn*" issue at length. According to their observations, the private sector "*creams the crop*." Aspray and Freeman depict patterns in the hiring of IT students as a pyramid. The students with the most education and training and the highest grades are hired by "*Tier One*" firms that currently pay the most. Lower-achieving students wind up employed in lower tiers.

Who's Getting the Top Talent?

Tier One - Hot Software Companies
- Software Start-Ups
- Software Publishers
- Wall Street and Fortune 500 Corporations
- Major Research University

Tier Two - "*Soft-Aware*" Companies
- Value-Added Retailers, Consulting Firms, Systems Integrators
- Aerospace Industry
- Software-Intensive Firms (e.g. computer hardware, communications, finance)

Everyone Else
- Other industries with incidental software
- Department of Defense
- Federal, State and Local Government

Synthesized from Aspray and Freeman, *op. cit*. and Minutes of the Texas University School-to-Careers Task Group, October, 2000.

Despite being the best available study at present, Aspray and Freeman's seminal work isn't sufficiently detailed to drive workforce development planning or curriculum revisions. Its value lies in the key points the authors raise:

- "*High technology*" must be construed as a characteristic of occupations.
- "*High tech*" occupations are scattered across all industries. They aren't deployed just in industries which design, manufacture and distribute advanced information technologies.
- Not all jobs in industries labeled "*high tech*" require mastery of technology. Indeed, the majority of jobs in the next decade will still require only low- to medium-skills.
- "*High tech*" is not a dichotomous (yes/no) variable. Rather, occupations can be arrayed on a continuum according to the ways in which workers relate to technology.
- Preparation for "*high tech*" occupations involves more than training people to use technology. The curriculum must strike a balance between technical preparation and substantive business and industry knowledge appropriate for each occupation.
- Any strategy, policy or initiative which is based on a shallow, industry-level conception of high technology is likely to underestimate skills shortages and, thus, miss the target with its remedies.

It's often said that the "*devil is in the details*." To figure out **why** the supply of appropriately trained workers fails to meet demand, we have to break occupations down into their requisite know-ledge skills and abilities. Only then can we pinpoint what is missing and how to remedy the situ-ation. To pilot test the application of these concepts to the Texas labor market, the CDR did some simple, basic research. As did Aspray and Freeman, we began by classifying occupations relative to their interaction with advanced technology.

This preliminary work by the CDR unit of the TWC is far from exhaustive. Nonetheless, it demonstrates a unique way of looking at technology from an occupational perspective. Whereas Aspray and Freeman offer descriptive labels for categories with intuitive appeal, our work looks at the knowledge, skills and abilities (KSAs) associated with specific occupations. (Detailed occupational analysis is made possible through the O*NET. The content model of the O*NET is based on extensive observations of duties and task as they are being performed and through systematic gathering of employer input on their occupational performance expectations.) Secondly, whereas Aspray and Freeman suggest a few sample occupations which might fit in each of the CRA's categories, our work examines all occupational titles in the O*NET. This level of detail is necessary if economic analysis is to be of use in guiding curriculum development and case management. Occupational KSA analysis is vitally important to students and workforce development program participants as they put together individual employment plans (IEPs). They must be able to rely on well-informed counselors to know what it will take to prepare themselves for careers in high paying, technology-driven jobs.

What is the O*NET?

The O*NET is an electronic database designed to consolidate much of the occupational employment information previously scattered across products developed under federal labor market research programs. It combines the richness of descriptive detail of the predecessor *Dictionary of Occupational Titles* (DOT), the employment statistics and projections previously available through the Occupational Employment Survey (OES), and the simplicity of the Standard Occupational Classification (SOC) coding system.

While one result of our study is classifying occupations as "*high-tech*," our objective is **to establish a relationship between job duties and the use of advanced technology**. We define "*advanced technology*" as systems that incorporate complex electronics (digital or sophisticated analog devices) as found in computers, lasers, robotics, and satellites as well as biomedical instruments and avionics. We then classify usage levels and label them according to level of technology. (See Table IX.)

Guidelines Used in the CDR Study

For the purpose of this study, we do not include basic wordprocessing or spreadsheet programs in the definition of technology. We do include information management systems built around relational databases.

Table IX

The Rubric Used in This Study to Describe Occupations According to Their Level of Technology-Intensity

Rank	Relationship to Technology
1	Job duties are driven by advanced technology.
2	Job duties require significant use of advanced technology.
3	Job duties rely on moderate use of advanced technology.
4	Job duties involve occasional use of advanced technology.
5	Job duties do not involve the use of advanced technology.

To derive the level of usage, we ask two questions: 1) **How often** does an employee use advanced technology? 2) **Why** does the employee need to use advanced technology to perform his or her job duties? Then we apply a metric to calculate the level of usage for each occupation based on three variables: time spent using technology; type of job duties in which advanced technology is used; and the purpose for using the technology. (See Table X.)

Table X

Operational Definitions Used in Applying the CDR's Technology-Intensity Metric to Specific Occupations

Rank	Amount of time spent using advanced technology	Type of job duties in which advanced technology is used	Purpose in using advanced technology
1	Constantly	Process or Product Research and Development	Program/Design Advanced Technology
2	Intermittently	Install, Repair, Set-up and/or Test Technology	Run Other Advanced Technologies
3	Daily	Operate Advanced Technology Equipment	Perform Specific Function/Process Information
4	Occasionally	Monitor Equipment	Extract Information
5	Never	Input Exact Information (Load/Unload Materials)	Input Information

Column two in Table X captures the frequency of use according to the following scheme for coding responses to "*How often is advanced technology used?*":

Constantly = advanced technology is used (in general) more than six hours per day.
Intermittently = three to six hours per day (not necessarily in one sitting).
Daily = one to three hours per day (not necessarily in one sitting).
Occasionally = no more than once per day (for less than an hour).
Never = used only on rare occasions — virtually never.

When workers are asked why they use advanced technology, two kinds of responses are likely. Column three in Table X captures responses which describe job duties or the worker's role when using advanced technology. The last column in the table captures the function or purpose played by advanced technology in performing occupational duties and tasks. For example, a Computer Scanner Operator operates a particular digital device (a scanner) to perform a specific function (scanning). Like the frequency variable, duties and functions can be ranked. In our tables, they are presented in descending order from highest to lowest in terms of the skills required.

The next step is to apply our metric to 691 OES-based occupations in Texas. Each occupation was cross-walked to a description in the O*NET and from the emerging and evolving occupations identified through prior research by the CDR (formerly known as the Texas SOICC). Using a scale of one to five, we selected the appropriate rank within each variable – one being the highest use of advanced technology and five being the lowest — for each occupation. The Computer Scanner Operator, for example, resulted in a "1.3.3" designation. This designation indicates that an employee in this position constantly (1) operates (3) advanced technology equipment to perform a specific function (3). We then derive the average rank from the resulting designation by totaling the digits and dividing by three. (For our purposes, each variable is weighted equally.)We round the result to the closest whole number: "*1,3,3*" corresponds to a rank of 2 because 1+3+3 = 7 and 7/3=2.33 which rounds down to 2. (See Table XI.)

Data Limitations

Occupational wage and employment projections data are collected by the TWC's Labor Market Information Department using the OES coding structure. The 691 titles represent occupations for which there are statistically reliable data and for which we can perform labor market analysis objectively. Collectively, these 691 occupations represent over 98 percent of total Texas employment.

See T. Ramsey, M. Anderberg, J. Pfeiffer and D. Whitfield, *The Study of Emerging and Evolving Occupations* (Austin, Texas: Texas SOICC, 1996); M. Anderberg, et. al. *Emerging and Evolving Occupations Study: Final Report 1996-1997* (Austin, Texas: Texas SOICC, 1997); N. Lewis and M. Anderberg *Emerging and Evolving Occupations Study: Final Report 1997-1998* (Austin, Texas: Texas SOICC, 1998); and B. Miller, *Texas Emerging and Evolving Occupations: Final Report 1998-1999* (Austin, Texas: Texas SOICC, 1999). Emerging and evolving occupations in Texas are listed at the CDR website and are imbed-ded in the SOCRATES planning software. See www.cdr.state.tx.us.

For those occupations where advanced technology is "*never used*," the other variables in the CDR's metric are considered irrelevant. In such cases, the denominator we use in calculating the average rank has to reflect the number of digits in the occupational representation. For example, a Taxi Driver who virtually never uses advanced technology would be represented digitally in our metric as "*5,<blank>,<blank>*." With only one usable digit in the representation, the formula for computing the average rank for a Taxi Driver would be 5/1 = 5 resulting in a rounded rank of 5.

Table XI

Scheme for Using Averaged Digit Totals on Three Rankings to Give Occupations an Overall Technology-Intensity Score

An Occupation's Digit Total	Average Ranking	Rounded Ranking	Verbal Description of Occupation-to-Technology Relationship (see column 2, Table IX)
3 - 4	1.00 - 1.49	1	Job duties are driven by advanced technology
5 - 7	1.50 - 2.49	2	Job duties require significant use of advanced technology
8 - 10	2.50 - 3.49	3	Job duties rely on moderate use of advanced technology
11 - 13	3.50 - 4.49	4	Job duties require occasional use of advanced technology
14 - 15	4.50 - 5.00	5	Job duties do not rely on the use of advanced technology

Assumptions

Various assumptions must be made when determining an occupation's rank on each variable. First, we assume that workers will use the most advanced digital or sophisticated analog technology that is readily available. For manufacturing-related occupations, we assume that equipment (e.g., a conveyor) being used on the shop floor is programmed by some form of computer system. We assume municipal governments will use Global Positioning Systems (GPS) and Geographic Information Systems (GIS) to improve operations in the Police and Fire Departments or Urban Planning or Public Works divisions. Other examples of our "*most advanced technology available*" assumptions include:

- elementary through postsecondary instructors occasionally use the Internet to search for information;
- supervisors use the technology of other workers as well as personnel information management systems; and

- automobile repair workers use computerized diagnostics tools.

Case Study Illustration

The Printing Industry provides excellent examples of how digital technology is transforming occupations. Steps like putting an image on photographic film and developing "*mechanicals*" (lay-outs of the final product for customer approval) are no longer necessary. Instead, digital cameras and photo-editing software are used to manipulate images on computer screens. After being edited, images can be transmitted to a customer via e-mail. For final production, orders are processed through computer-to-printer, computer-to-copier or computer-to-plate technology.

> National Association of Printers & Lithographers, *1997 And All That: Choice, Choice, and More Choice* Tech Trends Report 1, no. 6. (1998)

While many small print shops throughout Texas may not be using digital technology yet, we assume that most will upgrade their processes in the near future. (Shops that don't upgrade probably will be driven out of business by competitors.) As a result, most printing occupations (OES 89702 – 89719) received a rank of "*2*." We assume (based on the job descriptions) that some occupations in the printing industry still are not using digital technology; e.g., Hand Compositors and Typesetters (OES 89702), Job Printers (OES 89705) and Film Strippers (OES 89717). Not surprisingly, these occupations face low to negative growth in demand.

Our Findings

Our methodology works well. It results in ranks that make sense intuitively. Engineers who design technology rank higher than engineers who design structures. In manufacturing, Set-Up crew members who program computers to run machinery rank higher than Operators who simply use the machinery. The same holds true for Pattern-Makers as opposed to those who subsequently use patterns made by others to cut, mold and shape products. Likewise, in the Health Care Industry, technologists (who typically hold a Baccalaureate degree and perform some supervisory roles) rank higher than technicians (typically, Associate's degree or one-year certificate holders without supervisory duties).

Interestingly, we find that the use of information management systems places most clerical and financial occupations at a rank of "*3*" (i.e., where job duties rely on moderate use of technology). Similarly, increased reliance on "*enterprise resource planning systems*" raises inventory, shipping and transporting occupations to a rank of "*3*." Such examples emphasize the importance of using a KSA-based approach at the occupational level. **Without such detailed and careful empirical analysis, it is too easy to underestimate the technology-intensity of many common occupations.**

We aren't able to rank some occupations involved in sales or purchasing because the level of technology used depends on the product being sold or procured. For example, a Vacuum Cleaner Product Demonstrator virtually never uses technology and would rank as a "5" while a Computer Server Product Demonstrator would be represented digitally as "*1,3,2*" using the CDR's metric with a rounded rank of "*2*" (i.e., where job duties require significant use of technology). However, there isn't enough detailed information in the description of Sales Representative N.E.C. (not elsewhere classified) for us to use our metric.

High Technology and Labor Market Disparity

The CDR found that it can use this concept of "*technology-intensity*" to explain why employment demand is increasing in some occupations while flattening or decreasing in others — independently from the shifting fortunes of the industries in which they are deployed.

- Of the 638 occupations with usable data for assessing their technology-intensity, only eighteen are classified as being "*driven by technology*."
- Another forty-nine "*require significant use of technology*."
- Although digital technology has become quite pervasive in consumer goods and services, analysis based on the CDR's metric indicates that over forty percent of all occupations fall into the category where "*job duties do not rely on technology*." In Texas, that subset of occupations accounted for 43.3 percent of all employment in 1998.

As one might imagine, however, technology-driven occupations are likely to exhibit the greatest demand growth. Those which rely heavily on advanced technology are projected to expand by 33.7 percent between 1998 and 2008 — a rate almost double that for all occupations. For occupations "*driven by technology*," 65.9 percent of the projected job openings will be due to growth, as opposed to a need to replace existing workers. By contrast, occupations which "*don't rely on technology*" will have only 38 percent of their total openings due to growth (whereas the Texas job market as a whole will have 42.2 percent due to growth).

> **Absolute Demand vs. Growth Rate**
>
> It is important to note that, despite projected rapid growth rates, occupations in our top two technology-intensity categories still will only represent just under seven percent of the state's total employment by 2008. Conversely, 43.2 percent of total Texas employment in 2008 is projected to be in occupa-tions which don't rely very often on tech-nology.

Not surprisingly, those occupations which are either "*driven by technology*" or "*require significant use of technology*" will represent an ever increasing percentage of total employment in the Texas economy. Those which "*do not rely very often on technology*" will decrease as a percent of the state's total employment by the year 2008.

This research also substantiates several noteworthy hypotheses about technology and occupations. To perform effectively and productively in most occupations *driven by technology*, workers, on average, need to have slightly more than a baccalaureate education; i.e., at least a Bachelor's degree plus some work experience. On the other hand, *occupations which don't rely on technology* averaged an educational preparation period of one month's worth of OJT or slightly less.

Clearly, there are financial rewards to those investing both in education as a whole and particularly in educational programs associated with technology-driven occupations. The weighted average hourly wage for all occupations in Texas was $13.40 in 1998. In contrast, those occupations which rely heavily on technology average $23.37 per hour. Even those which require significant use of technology average $21.58. The weighted average hourly wage for occupations which do not rely on technology is only $9.03.

The results of our ranking of occupations by their level of technology-intensity are provided in the appendix to this report.

Recommendation #4: All occupations (both in the information technology related industries and in all other sectors of the economy) should be monitored constantly. We need to anticipate changes in the technology-intensity of occupations and the implications such changes will have in terms of the knowledge, skills and abilities required for occupational employment. Constant monitoring is the only way to give all stakeholders the early warning they need to plan strategically for education, training and workforce development.

A sound strategic plan requires reliable and valid data. Although readily available and frequently used to drive strategic planning, industry-level analysis of technology-intensity just is not detailed enough to be actionable. Data at the occupational level are decision-critical. When implemented, new technologies and processes have their most direct impact at the occupational level. As the technology-intensity of an occupation changes, so do the required knowledge, skills and abilities. If changes in essential KSAs are significant, incumbent workers will need to be re-trained. The curriculum for those who aspire to employment in existing but significantly evolving occupations must be updated while curricula to address wholly new emerging occupations may have to be developed *de novo*.

Long lead times are required when reshaping education and training programs to meet changing occupational employment demands. In addition to developing or revising the curriculum, other factors increase lead time requirements.

- Program approval and start-up funds must be obtained through rather cumbersome procedures. (The approval process may take longer for public secondary and postsecondary institutions than it does for independent education and training providers.)
- It may be necessary to procure and install new technologies in the classroom or learning laboratories. Publicly-funded education and training entities may have to go through a competitive bid process or government procurement contracts to obtain new equipment. Either route can be very time-consuming.
- Instructional faculty will need time to master the new or revised curriculum and to create or adjust their lesson plans, and prepare new lectures and supporting materials.
- Students and workforce development program participants must be made aware of changing occupational employment conditions and counseled to take appropriate course(s) to obtain the required KSAs.

"*Front end*" assessment instruments for filtering prospective students and trainees on the basis of aptitude and interest may need to be modified to reflect changes in the technology-intensity of the occupations to which they aspire.

"*Back end*" instruments for assessing the competencies of program exiters may need to be modified or created from scratch to reflect changes in the criteria employers use to screen applicants for emerging and significantly evolving occupations.

- Sufficient time must be built into the curriculum delivery model for students and trainees to complete any required, coherent sequence of courses or learning experiences.

- Planners, educational administrators and employers must have realistic expectations about the time it will take for appropriately skilled program completers to exit the pipeline. Completion times prescribed in course catalogs presume the curriculum can be delivered in a specified number of clock hours and that students with sufficient seat time will have acquired the essential KSAs. Catalog-prescribed completion times based on such assumptions constitute best case scenarios. **More often than not, catalog descriptions underestimate the true length of the education and training pipeline.**

Estimated completion times must be adjusted to take into account the decreasing likelihood that students will enroll full time in consecutive quarters until they complete all courses required for a credential.

Students — especially those referred for training through programs under the Workforce Investment Act or welfare-to-work initiatives under the "Work First" model of the Personal Responsibility and Work Opportunities Reconciliation Act — are apt to enroll only part-time.

Students with limited finances — especially referrals from welfare-to-work — are likely to stop-out and re-enroll in non-consecutive quarters or drop out altogether.

Estimated completion times also presume that all students learn at the same pace. Some students can handle an overload to complete an education and training program ahead of schedule. It's more common, however, to find students milling around during their first few semesters on campus. Many sample courses from "*the educational buffet*" instead of pursuing a focused career development plan. Many need to complete remedial courses and prerequisites before they can wade into their chosen field of study. Both remediation and unfocused exploration add to the length of time to completion.

See M. Anderberg, *Where are They Now: a Longitudinal Study of the 1994-1995 Exit Cohort from Texas Public Education* (Austin, TX: Texas SOICC, 1999).

Recommendation 4(a): Assuming that current labor market and occupational analysis should be at the core of workforce program planning and educational curriculum development, several funded positions should be identified and assigned the task of monitoring the technology-intensity of occupational employment in Texas. Their findings should be integrated

with occupational employment demand forecasts, new occupational taxonomies, detailed information on the KSAs required in each occupation, and supply side information on related education and training programs.

Comprehensive occupational employment analysis entails a variety of methodologies. Different entities currently are responsible for the separate activities.

- To obtain current occupational employment data and for forecasting future occupational employment demand, the Labor Market Information unit of the TWC conducts employer surveys. (Format and timing of the surveys are prescribed by the Bureau of Labor Statistics to ensure consistency in time-series data and cross-state comparability.)
- Two methods are used by analysts working under grants from the US Department of Labor to identify KSAs for each occupation in the O*NET.

  One method is to observe incumbent workers as they perform their duties and tasks. The knowledge, skills and abilities that come into play are recorded systematically by frequency, function, importance and level of difficulty. The other method is to obtain input directly from key informants. Informants include: incumbent workers, first-line managers and supervisors and in-house corporate trainers. Installers and support personnel from technology vendors also are in a good position to see how their equipment changes the way the clients' employees do their jobs. Key informant input is obtained through one-on-one interviews or through structured focus groups.
- Education and training providers are equally interested in occupational KSAs. Often, however, they work with researchers who use methods parallel to those of the O*NET contractors (e.g., V-TECS, SkillsNet, various national and state level skills standards boards, the WorkKeys group of ACT) or with their own advisory boards. Local advisory boards vary widely in their composition as well as in their methodological rigor and sophistication.
- The CDR, Computing Research Associates and various divisions within the US Department of Commerce are beginning to drill through layers of proxy indicators to assess the technology- and knowledge-intensity of specific occupations.

Unfortunately, each set of researchers is apt to use different taxonomies to code and store the data they obtain. It takes special staff expertise to: identify and facilitate the shared understanding of the commonalities that underpin disparate methods of occupational employment analysis; synthesize results obtained through different techniques; organize the information in a coherent, structured database; devise application software and report formats that help stakeholders understand and use the data to inform their own decisions.

> It is especially difficult to package the data in ways that can be understood and used appropriately by stakeholders who are not as statistically literate as those who do the initial research.

That kind of expertise is quite different from the expertise of policy-makers, curriculum developers, instructional faculty, or counselors and case managers. Moreover, stakeholders with other primary duties do not have time to gather, code, organize and analyze decision-critical information at the occupational employment level. Therefore, at least one labor market professional specially trained in job analysis techniques and organizational theory, optimally working under the direction of the CDR, should be assigned full time to do occupational employment analysis at the KSA level and coordinate the production of KSA-based materials for a wide range of stakeholders.

See M. Anderberg and R. Froeschle, *Roles and Responsibilities in a Performance Measurement System: Description, Prescription and Policy-Making* (Austin, TX: SOICC, 1997); Bristow and Anderberg, *Converging Paradigms (op.cit.).*

We recommend performing this kind of analysis and product coordination at the state level to enhance the connection between the statewide labor market information system and chief users in partner agencies. For example, a labor market analyst assigned these functions at the state level with the CDR could serve as an effective conduit of occupational level KSA-requirement information (verified by a large number of employer/informants and/or sufficient observations) to:

- task groups, subject matter committees and state agency staff working under the auspices of the Texas Higher Education Coordinating Board to develop and update the Workforce Education Course Manual (***WECM***);
- task groups, subject matter committees and state agency staff working under the auspices of the Texas Education Agency to develop and update the Texas Essential Knowledge and Skills (***TEKS***) section of public education's statewide administrative procedures manual;
- staff of the Workforce Development Division of the TWC responsible for issuing annual **WIA program planning guidelines** and technical assistance on **individual employability plan development procedures** to local boards and workforce centers; and
- other staff in the CDR and the LMI unit of the TWC responsible for automated planning and labor market targeting tools, career guidance software, supporting materials and technical assistance to local boards, regional education consortia (such as Tech Prep and School-to-Careers), workforce centers and service providers.

There will be variations among firms in the way workers with the same occupational titles are employed. Demand for employment in technology-intensive occupa-tions will vary from one local workforce board region to the next. There may be slight regional variations in what employers expect in the way of required KSAs for any particular occupation. Nonetheless, there generally will be a core set of competencies that need to be addressed in any occupationally-specific curriculum, guidance materials, student career assessments and job-search assistance efforts. Research conducted at the state level can establish a baseline set of KSAs for each occupation.

Validation to local occupational employment conditions and employer hiring criteria should be exercised by workforce boards, vocational advisory boards and regional education consortia.

What Role Should the Federal Government Play?

The federal government has avoided prescribing any education and training curriculum. However, the federal government could legitimately use its influence and resources to help **standardize occupational employment data collection and coding.** (This already is taking place in publicly funded research in which the Office of Management and the Budget requires federal agency to use the Standard Occupational Classification (SOC) taxonomy and in the O*NET's content model for organizing occupationally-required KSAs.) Standardization ensures comparability of data across states and disparate initiatives. Minimal coordination by federal agencies can help researchers avoid duplication of effort while learning from and building on each other's works. Moreover, if several pieces of research conducted by different parties in different parts of the country draw the same inferences from comparable data, all stakeholders can have more confidence in their conclusions. Thus, everyone will be more inclined to use research findings to drive strategic planning and career guidance.

While the Bureau of Labor Statistics continues to collect time-series data tied to employment structures of the past, the US Department of Commerce (DoC), in implementing OMB-ordered conversion to the SOC, is revising its monthly and annual surveys to capture more data on e-business, research and development activities, etc. (See the works of Atrosic and Jarmin, Haltiwanger et.al., and Mesenbourg et. al. cited in the bibliography for details on DoC's new data collection efforts. Also see bibliographic entries for Atkinson et. al., Barua et. al., the Financial Accounting Standards Board, Greenstein, Lev et. al., Morgan-Stanley, and the Progressive Policy Institute for other recommendations for standardizing the collection of data pertinent to the knowledge-based economy.)

The federal government legitimately can **serve as an information broker**. Results of research financed with federal dollars are in the public domain. Information (such as descriptions of best practices identified through federally-sponsored research) can be distributed freely without the government prescribing how that information should be used. Stakeholders can take research findings under consideration. If they are convinced that the research methods were rigorous and sound, they will use the findings to drive policies or individual choices voluntarily without the government resorting to prescriptive rules and regulations. To some extent, this already is being done through America's Learning Exchange which provides a nationwide inventory of education and training services from public and private sector vendors. (For details, go to http://www.alx.org.)

The federal government can **underwrite the cost of developing and providing universal access to automation tools** that stakeholders can use to communicate across the current chasm between the specialized languages of educators and employers. Useful tools would include but not be limited to crosswalks among various educational and occupational taxonomies (e.g., OES-to-SOC or SOC-to-CIP crosswalks) as well as web-based utilities to match openings posted by employers in America's Job Bank described in a common vocabulary and format with resumes constructed by job-seekers in America's Talent Bank. (For more details, go to http://www.ajb.dni.us.)

Lastly, the federal government can **facilitate consumer protection**. Federal dollars already are being used in all states to collect and display core performance information for education and training programs. Without prescribing the curriculum, venues or modes of instructional delivery and credentialing criteria, federal consumer protection efforts facilitate "*truth in training*," greater accountability and more responsiveness among education and training providers to customers' needs. (See, for example, consumer reports for Texas at http://decide.crs.state.tx.us.)

Recommendation 4(b): Effort must be made to go beyond gathering and synthesizing information about employer-specified KSAs for technology-intensive occupations. Strategies must be devised (along with possible rule changes) to ensure that these data are used effectively in strategic planning and career guidance.

Information accumulated, synthesized and repackaged by the aforementioned CDR's occupational employment analysts should play a prominent role in service delivery under the Workforce Investment Act and related occupationally-specific education and training programs. Recommendations 4(b)(1) through 4(b)(5) are not exhaustive. Nonetheless, they should serve to suggest where services need to specify goals and objectives in terms of occupationally-specific KSAs.

Recommendation 4(b)(1): KSA statements derived from occupational employment analysis ought to constitute the learning objectives of related occupationally-specific education and training.

- **The curriculum for occupationally-specific education and training programs ought to be built around employer-validated KSA requirements.**

  Even where the object occupation is not commonly employed in an IT industry, the curriculum should indicate how pertinent technologies are being implemented. This is equally important for emerging occupations and where shifts in technology-intensity are likely to transform the significantly evolving occupation's KSA requirements in the near future.

- **Program completion ought to be based on "*authentic assessment*." Assessment should be "*criterion-referenced*" rather than "*norm-referenced*."**

  This means students should be required to demonstrate their competency in each specified KSA rather than taking end-of-course "*multiple guess*" paper-and-pencil tests. Rather than being graded on a curve relative to their classmates (*norm-referencing*), students should be required to demonstrate competencies at a level of proficiency which prospective employers consider acceptable *(criterion referencing*). Regardless of the program area, **completion should be contingent on demonstrated competency in all technologies integral to job performance**.

- **A credential on its face should make it easy for prospective employers to determine what the student** (as a job applicant) **knows and can do.**

  Employers frequently complain that educational credentials signify only that a student has completed a specified number of clock hours or accumulated sufficient seat time. Employers prefer a credential that is more than a "*sheepskin*" with the graduate's name, institution, date and major on the front side. They prefer the "*guaranteed diploma*" that lists the credential holder's competencies and proficiencies on the back side.

- Alternatively, education and training providers can help students in their search for jobs in training-related fields by more fully documenting the content and assessment criteria for each course on the transcript. Faculty should encourage students to assemble portfolios that showcase their competencies. **Credentials, expanded transcripts and portfolios should be structured around employer-validated KSAs for related occupations.** These items collectively and separately ought to indicate clearly the student's level of "*fluency*" in technologies that are likely to be used on the job.

Fluency in Technology

The central education agencies of Arizona, Ohio and Wisconsin recommend that all high schools in their respective states require students to be "*fluent*" in technology before they graduate. These states have drafted model standards but have not yet enforced them. Beginning in School Year 2001-2002 the Massachusetts Board of Education will require "*engineering instruction*" in all grades (K-12).

See Galvin, op. cit.; Malyn-Smith, *op. cit*.; and National Research Council, *op. cit*. Arizona's model standards are described at http://www.ade.state.az.us/standards/ tech-nology; Ohio's are at http://itWORKS-Ohio.org/; Wisconsin's model standards are described at http://www.dpi.state.wi.us dpi/standards. See also N. Leaner, *K-12 Students Must Take Engineering Classes* Education Daily, Vol. 33, No. 243 (December 22, 2000).

A joint task force convened by the Association for Computing Machinery and the Computer Society of the Institute of Electrical and Electronic Engineers has published recommended guide-lines for a comprehensive computing curriculum (the CC2001) for computer science and related disciplines at the postsecondary level.

See Computing Curricula 2001 at http://www.acm.org/sigcse/cc2001/steelman/

- In seeking program approval and/or funding, vendors who provide occupationally specific education and training ought to state clearly the KSAs and proficiency levels that program completers are expected to achieve. Authorities responsible for program approval and funding ought to validate KSA objectives specified by education and training entities against employers' expectations that have been recorded systematically by the occupational employment analysis team.

For Example

These factors should be considered in the Texas Higher Education Coordinating Board (the THECB) approval of occupationally-specific postsecondary programs, the Texas Education Agency (TEA) review of secondary career and technical education programs, and local work-force development board reviews of applica-tions for vendor certification under the Work-force Investment Act.

Applications for program approval and funding ought to specify how KSA

requirements will be addressed by the curriculum, assessment at program exit and in the credentialing process.

Recommendation 4(b)(2): KSA statements should be the focal point of other kinds of services delivered through or brokered by the one-stop workforce centers.

Workforce center staff can arrange individual OJTs with specific employers. **Each OJT agreement should specify the KSA and proficiency outcomes the participant is to achieve.** Case notes should provide evidence that the case manager explained these factors to all parties to the OJT agreement. The employer who is to do the training and the trainee should acknowledge that they have been told about anticipated changes in relevant technologies and how those changes may impact occupational KSA requirements, future employment retention with the firm, possible career progressions and long-term earning potential.

Case managers should consult with the workforce center's labor market specialist about the anticipated employment opportunities and earnings potential of an occupation before arranging an OJT with the employer and trainee.

Ideally, OJTs should be arranged with firms that are in industries that: are driving local economic development; are above their industry's average in technology-intensity; pay more than the industry average; are growing at a faster rate than other local firms.

Ideally, OJTs should be targeted to occupations with an average rounded rate of 3 or less (i.e., at least where the "*job duties rely on some advanced technology*") on the CDR's technology-intensity metric (see Table XI) or which fall into one of the four IT-related groupings described by Aspray and Freeman (see Figure 2).

Sometimes the staff of a workforce center or the local workforce investment board will broker firm-specific or "*skills gap*" training.

Examples of Firm-Specific and "*Skills Gap*" Training

Firm-specific training might be brokered through Smart Jobs or the Texas Skills Development Fund (TSDF). Workforce centers also might help area businesses obtain contract training directly from a local public community college. Workforce investment boards might help secure funding on behalf of local industry groups for Skills Gap Training to address occupational demands currently being filled by disproportionate numbers of alien workers with H1-B visas.

Firm-specific and skills gap training ought to be targeted to specific high demand, technology-intensive occupations rather than to broad industry clusters.

Firm-specific and skills gap training contracts ought to specify the courses to be taught in standardized terms in the Workforce Education Course Manual (WECM) or Classification of Instructional Programs (CIP) taxonomy.

Any Requests for Proposal (RFPs) to secure firm-specific or skills gap training grants should require proposers to explain how technology change has impacted occupational KSAs and how those changes will be addressed.

Contracts for firm-specific and skills gap training should stipulate deliverables in terms of proficiency levels and competencies that program completers are to demonstrate in relevant technologies.

Student/participant outcomes for firm-specific or skills gap training should be recorded and certified in terms of KSA competencies demonstrated and proficiency levels achieved.

For maximum return on investment of public funds, firm-specific training should be targeted to companies that are: above average in technology intensity; in industries which drive local economic development; paying their workers at or above the prevailing industry wage levels; and growing at a faster rate than other local firms.

For maximum return on investment of public funds, firm-specific training should be targeted to occupations with an average rounded rate of three or less (at least where the "job duties rely on some advanced technology") on the CDR's technology-intensity metric (see Table XI) or which fall into one of the four IT-related groupings described by Aspray and Freeman (see Figure 2).

Special Initiatives

Several public officials (including the Governor, members of the Texas Workforce Commission, state legislators, the State Board of Education, and members of the Texas Higher Education Coordinating Board) have toyed with various ideas for earmarking special funds to pay for *"high technology*" training. Special initiatives should be treated in the same way as firm-specific and skills gap training programs. To achieve optimal results, *special initiatives should focus on the KSA requirements of specific high demand, technology-driven occupations* rather than being geared generically to broad industry clusters that are labeled "*high tech*" inappropriately. Occupational employment analysts, for example, should be consulted to help draft RFPs and proposal evaluation criteria for special high tech initiatives. Neither naive euphoria nor rhetorical intonation of the "*high tech mantra*" should short circuit the process for carefully evaluating each proposal.

Recommendation 4(b)(3): An entire unit should be added to the middle school career investigation curriculum to address the essential elements of technology change and its impact on the students' future employment and earnings. The connections between technology change and requisite KSAs for occupational employment in high wage, technology-driven fields should be reinforced throughout the remainder of coherently sequenced courses in every career cluster.

Middle school students need a broad understanding of labor market dynamics. As they enter the long education and training pipeline to high paying, technology-driven occupations, middle school students are ill-served by a static view of their career options. Jobs currently open will have been filled long before they graduate from high school. One of the most important things to emphasize in career investigation courses at that early stage is that virtually all jobs are being transformed by technology and wholly new, unanticipated career options may be open to them by the time they leave high school or college. It is critical that young students get a fundamental grasp of the way technology transforms occupations, employment opportunities and wage structures **before** they devise an individualized graduation plan in collaboration with their parents and counselors. Those who do not grasp the fundamental relationships early in their career investigation process are likely to close the doors prematurely to viable options.

As will be discussed later in this report, ill-informed students too often avoid taking the rigorous "*gatekeeping*" courses in mathematics and science. One might gain admission to college having completed only the bare minimum high school math and science requirements. Admission to a college does not guarantee that a student is prepared to handle the academic prerequisites of technology training. And, where employment demand for graduates is great, technical programs may have a waiting list. Postsecondary institutions often look for the rigorous math and science courses on applicants' transcripts when sorting out who will be admitted to programs related to high paying technical jobs.

To be sure, the relationships among technological change, occupational employment and appropriate education and training options are complex. Nonetheless, middle school students should be able to grasp the fundamental concepts if the learning modules in the curriculum are illustrated with a few clear examples. Simple classroom materials can be devised to intrigue young students about the use of robotics to transform the conventional, labor-intensive assembly line. A practical and fun shopping expedition exercise can show them how e-commerce has changed the way retail sales of youth-oriented products are handled. A story about tracing the "*Love Virus*" to a hacker in the Republic of the Philippines can dramatize how technology has transformed the role of the conventional police officer into that of "*cyber-detective.*" In-class illustrations can be reinforced with homework assignments to interview parents, neighbors or relatives about the way technology has changed the way they perform their job duties.

Over time, the students' grasp of these connections can become more sophisticated as more attention is devoted in coherently sequenced courses to discussions about the way relevant technologies have transformed the specific career clusters of greatest appeal to them. Term paper assignments in later grades might require students to make educated guesses about the technology changes that might lie just over the horizon in their chosen career fields. Field trips, internships and in-class presentations by incumbent workers in technology-driven occupations can help the students identify patterns of change.

See R.B. Bristow and M. Anderberg, *Career Majors in Texas Public Education* (Austin, TX: Texas SOICC, 1996); and R. Froeschle, *Education Systems Building and the Use of the Career Majors Concept* (Austin, TX: Texas SOICC, 1999).

Where possible, students should have enough hands-on experience with the technology relevant to their career choice that they can demonstrate their competency and proficiency by the time they exit a coherent sequence of courses.

Forthcoming Products from Career Development Resources

By the winter of 2001, the CDR unit will deliver two products that counselors and instructors faculty can use to help students understand connections among technology change, occupational employment and related education and training options. The first is funded by the Texas School-to-Careers (StC) Office. The second is funded by the federal Office of Vocational and Adult Education (OVAE) through the network of state entities set up under §118 of the Carl D. Perkins Vocational and Technical Education Act of 1998 (Perkins III) to address labor market issues confronting K-12 and postsecondary education.

The project funded with OVAE dollars will deliver professional profiles on 20 occupations. The profiles will be based on interviews with workers in prestigious positions which require intensive study of math and science. Interviews already have been conducted, for example, with scientists, engineers and technicians at the Johnson Space Center operated by the National Aeronautics and Space Administration (NASA) in Clear Lake, Texas. The CDR's interview protocol includes questions regarding the impact advanced technology has had on the way their work is done and on the KSA requirements of their occupations. While data underpinning these forthcoming professional profiles will be gathered systematically, the information will be presented in anecdotal form to engage the interest of middle school and high school students. Our aim is to help them think more clearly about the gateway courses they should take to keep open a wide array of options leading to high paying jobs in technology-driven careers. The S-t-C-funded project will deliver curriculum-related materials comprised of labor market information to enhance career investigation capacities of instructors and counselors. The primary rationale for developing curriculum-related LMI materials is expressed in the CDR's grant application to the Texas S-t-C Office:

> *"Tremendous career opportunities in the sciences and information technology fields are being overlooked in favor of overcrowded social science and liberal arts fields to the detriment of students, employers and society in general. . . It is our vision that a well-informed faculty will have an impact on the alignment of student career goals and their education requirements* [to] *produce. . . A workforce that is capable of dealing with the volatility and change* [in] *the global labor market* [faced by] *the next generation."*

One section of the curriculum-related LMI materials will deal expressly with the impact of technology change on occupational employment and occupational KSA require-ments.

Recommendation 4(b)(4): KSA requirements should be the focal point of case management in workforce development and career counseling in public education.

- **Each Individual Training Account (ITA) voucher issued under WIA should specify the customer's learning objectives in terms of KSAs for occupations on the local workforce investment board's target list.** Those KSAs should match the learning objectives of courses offerings of vendors certified by the local workforce board for delivery to WIA-eligible participants. Backup documentation should be maintained in case notes — with signatures from both the case manager and the trainee — attesting to their collaborative review of the KSA objectives stipulated on the face of the trainee's ITA voucher. Workforce center case managers should annotate their discussions with customers about any impending technology changes in the customer's chosen field and how those changes are likely to impact required KSAs and occupational employment demand.

- Graduation plans for Career and Technology Education (CATE) students are devised in collaboration with parents, counselors, CATE faculty and sometimes a representative of the industry most closely related to the student's field of study. **The graduation plan for each CATE student, ought to specify:**

  what KSAs and proficiencies the student is to acquire and demonstrate;

  how those KSAs relate to local occupational employment demand and the student's earnings potential;

  how any anticipated changes in relevant technologies are likely to affect occupa-tional KSA requirements, postsecondary learning objectives and future employ-ment prospects in the student's chosen career field;

  how those KSAs relate to subsequent pursuit of additional education and training — particularly for Tech Prep programs specifically articulated with course offerings at nearby postsecondary institutions; and

  how the student's KSAs and proficiencies will be communicated to prospective employers and postsecondary institutions.

Recommendation 4(b)(5): More attention should be given to advanced career investigation while students are pursuing concrete majors at the postsecondary level.

Most students enter postsecondary institutions without a firm grasp of technology's impact on labor market demands or occupational KSA requirements. Some fortunate students may have been introduced systematically to the fundamentals of labor market dynamics through career investigation courses and data-oriented counseling in middle school and high school. Others may have acquired a modest understanding of the labor market through self-study, through astute parental guidance or because they received special attention from a well-informed teacher or mentor. Nonetheless, even the most well-advised incoming students must fine tune their postsecondary course selections to address the ongoing dynamics of technology change in their chosen career fields.

Fine-Tuning Postsecondary Majors and Course Selection

When Juan arrives on a college campus for the Fall term, he's better off than most incoming students who go to postsecondary institutions immediately after finishing high school. Most of his peers don't have a clue about what they want to be. (Indeed, about 40% of Johnny's classmates have no declared major in their first semester on campus. Another 25% have relatively non-specific majors like Liberal Arts, General Studies and Multi-disciplinary Studies). At least Juan is he convinced wants to be some sort of scientist. However, in the Standard Occupational Classification (SOC) taxonomy there are ten unique job titles containing the name, "*scientist*" and that count doesn't even include all the sub-specialties in the science departments on his campus.

Since she did her initial career exploration in seventh grade, Thuy has been certain that she wants to major in something that will get her a job working with computers. With the help of her middle school counselor and the instructor in her Career Investigation class, Thuy explored what the Computer Science discipline was like in 1995. Thuy knew what gateway courses she should take in high school. She took all the math classes to the highest level offered in her school district and earned *A*s in all of them. She also took a course in Basic Programming at her high school and earned an *A* in that as well. At home, Thuy used free utilities offered by her Internet access provider to set up her own homepage. She arrived on campus with books borrowed from her oldest brother who majored in Computer Science ten years earlier. She is all set to study Pascal, Cobol and Fortran. Unfortunately, those courses are no longer offered by the college.

Following the recommendations in *Computing Curricula 2001* issued by the Association for Computing Machines and the IEEE, Thuy's college divided its Computer Science program into four separate but overlapping majors: Computer Science, Computer Engineering, Software Engineering and Information Systems. She is advised that programming fundamentals and the study of specific languages will constitute about 30 percent of the core curriculum. In addition, the catalog indicates that Thuy will be required to get a taste of Discrete Structures, Algorithms and Complexity, Architecture and Organization, Human-Computer Interaction, Graphics and Visual Computing, Intelligent Systems, Information Manage-ment, Software Engineering, Operating Systems, Net-Centric Computing, and Social and Professional Issues before she specializes in any one of those areas. Not unlike Juan, Thuy grossly underestimated the number of alternative pathways to her career aspirations and the new twists entailed in each pathway. Although she got an early start in her career exploration, Thuy received no additional guidance in high school. She arrived at college unaware of the major changes in Computer Science that had occurred since she was in middle school. Now she must rethink her entire college major and graduation plan.

Because he loved Chemistry in high school, Bill wants to be a Pharmacist. During the summer before heading off to college, he ran across several articles in *Science* magazine and the *Scientific American* on the Human Genome Project. Both articles forecast that work to unravel the genetic codes imbedded in our DNA structure will revolutionize the way we fight diseases. Rather than get an undergraduate major in Chemistry, Bill now plans an inter-disciplinary major combining Chemistry, Biology (with an emphasis in Genetics) and Physics (with an emphasis on nano-structures).

Sam most admired his high school Math teacher and wanted to follow in her footsteps. When he arrived on campus, Sam was told that his college no longer offers an Education major. Certification rules now require aspiring teachers to major in the substantive field they want to teach. Sam declared Math as his major. As he enters his junior year, he is confronted with choices. To be a teacher, he needs courses in Education if he wants to be certified. On the other hand, he realizes that there is far more money to be made in the private sector. If he switches his career aspirations, Sam will have to take more higher level courses in theoretical mathematics instead of Pedagogy and Practice Teaching.

Large numbers of students across the nation — regardless of their field of study — complain that they receive too little information from their postsecondary institutions to guide their career choices and a rational selection of courses. Student advising offices in many places are under-funded. Moreover, they tend to focus on helping students understand the institution's graduation requirements and internal policies. Career decision and placement often is left to the student's faculty advisor. The faculty advisor is likely to be too busy with teaching, research and admin-istrative duties to have time to study the labor market. Unless trained in labor market economics, the student's advisor may not know where to turn for appropriate information. Postsecondary student surveys reveal that career guidance received from faculty advisors: tends to be biased toward the advisor's own narrow field of specialization within the discipline; is disposed *a priori* toward career pathways that run through graduate school to academic employment; and conveys implicit (if not overt) contempt for alternatives; i.e., non-academic careers.

For results from surveys of students from a large number of schools across a wide range of disciplines, see C. Golde and T. Dore, *At Cross-Purposes: What the Experiences of Today's Doctoral Students Reveal About Doctoral Education* (Philadelphia, PA: The Pew Charitable Trust, 2001). Sentiments expressed by a broad range of doctoral students are echoed in discipline-specific studies conducted by their respective profes-sional organizations. See, for example, H. Hiatt (chair), *Addressing the Nation's Need for Bio-Medical and Behavioral Scientists: A Report from the Committee on National Needs, Education and Career Studies Unit, National Research Council* (Wash-ington, DC: National Academy Press, 2000); M. Nerad and J. Cerney, *From Rumors to Facts: Career Outcomes of English Ph.D.s,* Council of Graduate Schools Communicator Vol. XXXI, No.7 (Fall 1999); Woodrow Wilson National Fellowship Foundation, *The Humanities Ph.D. and Careers Outside the Academy: Conference Proceedings* (http://www. woodrow.org/ conferences/); S. Gilbert, *Final Report of the Modern Language Association's Committee on Professional Employment* (http://www.mla.org/reports); National Academy of Sciences, *A National Conversation on Science and Engineering Doctoral Education* (http:/www4. nas.edu/); and S. Tighman (chair), *Trends in Early Careers of Life Scientists: A Committee Report,* (Washington, DC: National Academy Press, 1998).

> A common theme expressed by former students — surprisingly, not just from the Humanities and Liberal Arts but also from the Sciences and technical fields — is disap-pointment in their faculty advisor's unfam-iliarity with and inattention to technologies outside the advisor's own narrow field of specialization with a discipline. Also most faculty advisors — in the opinion of students — don't grasp the implications of technology change on career alternatives outside aca-demic research and teaching.

One solution is to **upgrade the career guidance role in the Student Services division of postsecondary institutions** where the function is adjudged to be weak by students and peer review.

> See Froeschle, Anderberg and Dimmitt, *op. cit.*

Another solution is to **include all publicly funded and volunteer private institutions' baccalaureate and post-baccalaureate programs in Texas's Automated Student and Adult Learner Follow-Up System.**

> See R. Froeschle, *Creating an Information-Based, Market Driven Education and Workforce Development System: the Role of Labor Market and Follow-Up Information* (Austin, TX: Texas SOICC, 1996); and recommendations by Dr. Neal Smatresk, Dean of Sciences, University of Texas at Arlington in personal exchanges with the author of this report, Marc Anderberg.

Results from follow-up on former baccalaureate and post-baccalaureate students should be included in Texas's automated consumer information system, DECIDE, to provide subsequent cohorts with the data they need to make informed career choices. Texas's consumer report system (located at www.decide.cdr.state.tx.us) currently focuses on results achieved by former students from the state's public community and technical colleges and volunteer proprietary schools.

> See M. Anderberg's proposal to the U.S. Department of Labor's Employment and Training Administration on behalf of a multi-state America's Labor Market Information System (ALMIS) Consortium for Consumer Reporting, 1995.

To be fully effective, these recommendations for formal action need to be accompanied by behavioral changes on the part of postsecondary faculty who heretofore have shown too little regard for student aspirations toward career alternatives outside their advisor's narrow field of specialization. While there is wide consensus in the recommendations across the studies cited on the previous page, the various professional associations differ in their opinions about who should be responsible for setting the tone within postsecondary institutions. Some of the task forces recommend that the leadership should come from departmental chairs. Others suggest that it should be the function of the deans to encourage faculty to provide students more information about alternative career options and to counsel all students to cross over the boundaries between disciplines if necessary to get the training they need in relevant technologies.

Where the postsecondary institutions do not have sufficient resources to upgrade the career guidance function of the Student Services office and where appropriate incentives are not in place to encourage faculty to render advice to students about alternative career options, separate advanced career investigation courses should be offered at the division or departmental level to incoming freshmen.

A career investigation course would focus on division- or discipline-specific occupational employment opportunities. It would cover topics such as: job placements and earnings among the discipline's former students and future job opening projections; emerging occupations closely related to the field of study; discussions about anticipated technology change in the discipline and its potential impact on occupational KSA requirements; testimonials from students who secured alternative (especially non-academic) or nontraditional (relative to their gender or ethnicity) employment in fields related to their training; and the "seed corn" issue — graduates who go into teaching jobs at the elementary and secondary level to help lay the foundation for later generations who want to enter the discipline. If offered to incoming freshmen, the career exploration course might provide an overview of the syllabi of upper level courses available from the department with special emphasis on: the learning objectives of each, the KSAs to be achieved by successful course completers and the connection of those KSAs to occupational employment opportunities.

This suggestion might require a change in current rules from the THECB and/or the U.S. Department of Education. At present, very few public postsecondary institutions in Texas offer career investigation courses. While Texas institutions are not prohibited from offering such courses, THECB rules prevent them from funding career investigation courses with state dollars. In the opinion of Dr. Neal Smatresk, Dean of Sciences for the University of Texas at Arlington, state funds would be well spent insofar as a career investigation class would help students:

- appreciate the full range of occupational employment options within their field of study and, perhaps find a countervailing force to off-set the unconscious predisposition of their instructors and faculty advisors toward certain career options;
- understand the employment prospects, earnings potential and prevailing working conditions in discipline-related careers;
- avoid milling around and, thus, shorten their time-to-completion by focusing on required occupational KSAs;
- tailor appropriate combinations of courses within their primary discipline and outside electives as necessary to master the technologies most relevant to their career choices; and
- identify and form supportive networks with like-minded classmates who intend to pursue comparable careers.

Best practices from the School-to-Careers transition model currently being imple-mented in K-12 and technical

Some Successful Examples of Career Exploration at the Postsecondary Level

Some states permit postsecondary institutions to use state dollars to fund advanced career investigation courses, mini-courses, workshops and seminars. Where this approach is permitted, students praise the efforts and rate the programs "*very useful.*" Physicist Brian Schwartz used NSF funds to create a course at Brooklyn College in New York City to enhance employment opportunities for physical scientists and engineers "*especially in occupations using newer technologies.*" Yale students put together their own seminar series on nontraditional careers in bioscience. Career investigation, particularly of nontraditional career options, also is available through the curriculum at Vanderbilt, the University of Pennsylvania, Duke, and Stanford. See the National Academy of Science's Career Planning Center for Beginning Scientists and Engineers at http://www2.nas.edu/cpc.

education at two-year postsecondary institutions should be used to guide similar efforts in traditionally academic programs offered by two-year institutions, in baccalaureate programs and in post-baccalaureate programs. This would include such practices as arranging training, paid internships, and summer work-experiences in business and industry jobs related to the student's field of study. (A task group of professors from Texas's four-year institutions has been formed to identify ways of emulating the best practices of the School-to-Careers initiative in baccalaureate degree programs and beyond. The task group is chaired by Dr. Neal Smatresk, Dean of Sciences for the University of Texas at Arlington.)

Recommendation 5: Revise rules and procedures to accelerate the delivery of an updated curriculum for education and training targeted to technology-driven, high growth occupations.

To meet rapidly changing KSA requirements in technology-driven, high growth occupations, it's not enough to update curriculum content. The education, training and workforce development system also must accelerate delivery of the updated curriculum. Recommendations 4(b)(1) and 4(b)(2) deal with ways to ensure that curriculum revisions are driven by the best available evidence about changing technology at the occupational level and the impact anticipated changes will have on occupational KSA requirements, employment opportunities and earnings potential. Recommendations 4(b)(3) through 4(b)(5) address ways to improve the delivery of information about rapidly changing occupational employment demands and related education and training choices to students. Recommendations 5(a) through 5(c) address ways to accelerate the delivery of an updated occupational education and training curriculum.

Recommendation 5(a): Re-examine the way new programs at public postsecondary institutions are funded.

Recommendation 5(a)(1): Establish a contingency fund for program start-up at public postsecondary institutions.

Most new program offerings require postsecondary institutions to hire additional faculty and find classroom space. New technical programs may require costly equipment and laboratories. But in the biennial funding process, most available public dollars are already committed to and encumbered by existing programs. Moreover, because the state's postsecondary budget has not kept pace with increases in the cost of delivering education and rising enrollments, funds are tight. That creates — at least early in the life of a new program — a zero sum game. Any dollars allocated to new programs must come from cuts, sacrifices and savings made elsewhere. But there is little room to squeeze needed start-up dollars out of existing programs. Once a new program at a public postsecondary institution has been approved by the Texas Higher Education Coordinating Board, there often is as much as a two year lag before tax dollars flow to it. Meanwhile, postsecondary institutions are expected to cover the costs of new program start-ups with local dollars.

In defense of the budgetary process, we must acknowledge that the rules do provide the stability and predictability necessary for operational planning by postsecondary institutions. Existing programs have ongoing expenses for equipment and laboratory maintenance (if not expansion and improvements of their own) plus contractual obligations to their tenured faculty and a commitment to their declared majors. The planning process would be thrown into chaos if the funding requirements of new programs took precedence over commitments to existing programs.

Local dollars are hard to find. Postsecondary institutions are no less committed than the THECB to existing programs and find it equally difficult to make cuts and sacrifices in them for the sake of funding new programs. Added to the zero-sum budgeting predicament, new programs face a Catch 22. Until they begin enrolling students, new programs can't document student demand as a way of justifying their budget requests for state dollars. Without students they can't generate tuition revenues. Without an allocation from the state or tuition dollars, institutions are hard pressed to hire the faculty, buy the equipment and build the laboratories they need to make their newly approved programs viable and attractive to students.

A partial solution would require the creation of a contingency fund at the state level expressly earmarked for covering the cost of new program start-ups. The fund would be ad-ministered by the THECB. The decision rules for allocating the contingency fund might include formulas for assigning weight to evi-dence of labor market demand in an emerging occupation tied to a newly approved program. Additional weight might be given to equip-ment or laboratory cost variables. Local dollar matching at some specified ratio also might be required. Rules governing the deactivation or termination of existing programs and intra-institutional shifting of funds might be loosened in order to help colleges and uni-versities find the resources they need to cover new program start-up costs while they wait to stake a more permanent claim in the next biennial budget.

Private institutions and nontraditional education and training providers (e.g., hardware and software vendors, community-based organizations) may be able to shift gears more rapidly. They are not tied into the state's biennial budgeting process. They may rely more heavily on non-tenured, at-will adjunct faculty. When market research indicates sufficient demand to anticipate a profitable return on investments in new equipment and laboratory space, they have greater freedom to shift funds around to create new programs.

The traditional higher education system is constrained by its inability to change directions quickly. This results from its limited resources to allocate to new or growing disciplines, the long-term commitment colleges and universities make in buildings and capital equipment or in tenured faculty appointments and its deliberative style of decision-making."

Aspray and Freeman, *op. cit.* — see especially Chapter Three.

Recommendation 5(a)(2): Make it easier for public postsecondary institutions to enter into

collaborative arrangements with the private sector.

Some postsecondary institutions are saddled with formal rules and informal traditions that are rather hostile to collaborations with business and industry. They deal with the private sector at arms length because some postsecondary leaders and faculty worry that collaboration could "threaten their academic missions by influencing what kinds of research is done and even what is taught." That posture works to preserve the autonomy of academe, safeguards it against "becoming the research-and-development arm" of corporations and against the "vocationalization" of education. The trade-off is that by distancing themselves too much, educational institutions risk being ignored by the business community for being unresponsive to labor market demands.

Educational institutions make altruistic requests for corporate contributions (whether in the form of equipment donations, cash donations to the endowment fund or requests for increased taxes) with "no strings attached." Such requests fall on deaf ears if business and industry leaders are unimpressed with the knowledge and skills an institution's program completers. Some employers believe they get a better return by investing in other kinds of educational venues. An ever increasing number of corporations are creating their own education and training programs. Some of these programs are designed to train workers to use their products and, thus, make their wares more attractive to their customers (e.g., Cisco, Novell and MicroSoft offer certification programs in their latest technologies). Others are designed to give their own employee the knowledge, skills and abilities needed to succeed in the rapidly changing work-place (e.g., Motorola University). Some are entering into collaborative arrangements with private, for-profit education and training providers that are less insistent on dealing at arm's length (e.g., DeVry Institute, ITT Technical Institute).

Some public institutions are reconsidering their stance *vis a vis* collaboration with the private sector. Policies regarding intellectual property rights, indirect costs, conflicts of interest and conflicts of commitment are being reviewed to determine how a better balance can be achieved to preserve a modicum of institutional autonomy while becoming more responsive to business and industry. Business and industry are more likely to help underwrite the costs of new pro-gram start-up if they are convinced that public postsecondary institutions accept them as equal partners.

See J. Bassiner, *op. cit.;* Business-Education Forum, *op. cit.;* Etzkowitz, *op. cit.,* and Leslie and Slaughter, *op. cit.*

Recommendation 5(b): Provide education and training on demand.

Postsecondary credentials are tied to the accumulation of course credits. Courses, by and large, are offered on a fixed schedule in brick and mortar classrooms. Schedules are dictated by the availability of faculty members, the academic calendar and the number of clock hours presumably required for a subject's mastery. That makes it easy to manage classroom space, account for faculty effort, bill students for the delivery of instruction and maintain quality assurance. This conventional arrangement presumes that students can and will adapt their schedules around the courses they need and, if necessary, will travel to the brick and mortar campus. That model of education and training may work well for traditional students who go directly from high school to college without financial obligations that require them to work full time.

Boom in IT Training Poses Challenges for Higher Education

The caption atop this page comes from a feature article in the November 6th edition of the *Chronicle of Higher Education* (2000). Sounding the alarm to the *Chronicle*'s readers from traditional postsecondary institutions, the article focuses on the worldwide growth of certification examinations in the field of information technology outside the traditional colleges and universities. As of November 2000, the informal count by the U.S. Department of Education (DoE) of such certification examinations was 300. Among the most prominent players in the certification by examination arena are Microsoft-authorized trainers, Cisco Academies, Oracle and Novell. The list continues to grow.

Between 1996 and 1998, the portion of certificate holders without a baccalaureate degree went up from 19 percent to 37 percent.

These programs don't pretend to be well-rounded higher education. They are narrow, fairly product-specific and application oriented. But, according to Clifford Adelman of the DoE, traditional postsecondary institutions ignore these certification by examination programs at their own peril. Employers and prospective students are paying attention to them and policymakers are sitting up and taking note.

The very existence of these programs serve notice that traditional learning and certification may not be necessary for high wage employment in some technical fields. Certification by examination is the epitome of venue-neutral, modality-neutral assessment. They measure competencies - knowledge, skills and abilities valued by prospective employers who deploy a particular vendor's hardware or software in the workplace. Because the certification is awarded by examination, the traditional institution's role is downplayed — indeed might be eliminated for those who can learn on their own or through on-the-job training.

While traditional postseconday institutions "mouthed off a lot about competency-based assessment in the 1970s and 80s," they didn't do much with it. The recent surge in certification by examination outside the traditional institutions has done more to promote widespread acceptance and status of the concept than 20 years' worth of idle talk by education reformers.

See C. Adelman (below)

Because employers respect these certifications and because they can be obtained by individuals studying at their own pace, policymakers now allow federal dollars to be used by WIA and welfare training program participants to cover their costs.

See G. Blumenstyk, *Boom in IT Training Poses Challenges for Higher Education* in Chronicle of Higher Education (November 6, 2000); C. Adelman, *A Parallel Postsecondary Universe* (Washington, DC: U.S. Department of Education, 2000); the Department of Labor-sponsored America's Learning Exchange at http://www.alx.org; and Information Technology Association of America, *When Can You Start? Building Better Information Technology Skills and Careers* at http://www.ita.org (2001).

Corporate Education

Corporate education rapidly is becoming a viable alternative to traditional higher education. In the past thirteen years, more than 100 four-year colleges in the United States have closed while the number of corporate universities went from 400 to more than 2,000. Major players include Motorola, Ford, IBM, and Barnes and Noble. Also noteworthy are the for-profit institutions which demonstrate a willingness to collaborate with companies to create firm-specific training (e.g., University of Phoenix). At the current growth rate, corporate universities will outnumber traditional institutions within the next decade — and probably sooner.

According to the National Adult Literacy Survey, approximately 53 percent of postsecondary education currently is delivered outside of traditional institutions. Nontraditional education providers (cor-porate universities, in-house training and hardware and software vendors) capture approximately one additional percentage of the postsecondary market each year. Corporate e-learning will earn an estimated $23 billion by 2004. Non-IT content will account for 54 percent of the subject matter.

IDC Research, *Corporate Learning Market to Skyrocket* at http://www.nua.ie/surveys/ (March 2, 2001).

Advances in information technology freed corporations from ties to local colleges. Increasing competition presents a significant threat to an education establishment that has had a monopoly since the Middle Ages. Until recently, colleges enjoyed a captive market. Corporations paid whatever institutions charged for executive education. Business and industry accepted whatever the college thought worthy of teaching and awaited instruction on the institution's timetable.

Private companies find it advantageous to form their own training entities or join in consortia even with competing firms in the industry to form their own universities. A corporate university allows them to coordinate and manage the education and training of their employees, customers and sup-pliers. Many find they can develop courses faster and at a lower cost than can traditional institutions that are saddled with procedural rules and higher overhead. There also seem to be cultural differences between the bottom line oriented pragmatism of the corporate world and the more theoretic world of academe.

Creation of a corporate university signals a firm's commitment to the lifelong learning of its employees. They can make the programs learner-centered rather than teacher-centered. Using latest state of the art technology, they can make their courses available on demand — twenty-four hours per day, seven days per week. Employees can take the courses at their convenience, not at the convenience of the instructor. They can learn at their own pace.

Having developed courses to meet the parent firm's internal needs, corporate universities learn that they also can educate their partners all along the supply chain about their business model, technical requirements and quality assurance policies. After bringing in the supply chain partners, corporate universities figure out that the parent firm's practices can be generalized to other situations and, thus, their courses may be valued on the outside. So firms discover they can generate revenue by opening enrollment in their corporate universities to the general public.

Yet there is ample opportunity for traditional colleges to capture some of this market. Ninety-two percent of corporations still out-source their employee training; 62 percent of those that offer their own training out-source curriculum development. Partnerships between corporations and universities, however, require the latter to develop a better understanding of and appreciation for the need and views of the former.

See J. Meister, *The Brave New World of Corporate Education*, Chronicle of Higher Education (Feb. 9, 2001) and *Corporate University Lessons in Building a World-Class Work Force* (New York City, NY: McGraw Hill, 1998).

That model, however, does not work as well for older, nontraditional students. They work during the day when faculty are most willing to teach classes. Their work schedules might leave them time to devote to learning only at night or on weekends. They may reside far from any brick and mortar campus. To avoid being laid off or to remain productive in the rapidly changing workplace, they may need training so urgently that they can't wait for the start of the next semester. They may need only brief training of less than a semester's length to acquire the knowledge, skills and abilities they need. They may be better served by open-entry, open-exit, self-paced modules that can be accessed from their home or work twenty-four hours per day, seven days per week. In the literature, the alternative to the conventional approach is called "education and training on demand."

It may be more difficult — but not impossible — for postsecondary institutions to provide quality assurance for distance education. For some learners, something may be lost in the absence of the face-to-face classroom experience. Nonetheless, education and training on demand would reach a talent pool that otherwise would go undeveloped. It also is necessary to address the churning phenomenon (described earlier) where incumbent workers may lose their jobs if they don't upgrade their skills. More research needs to done on best practices in distance education that maintain high academic standards and on supplemental processes for providing distance learners some facsimile for face-to-face contacts with mentors and classmates.

What matters most to employers and the workforce is the acquisition of appropriate knowledge, skills and abilities — not the convenience of the faculty and the ease of administration. Unless public postsecondary institutions do more to accommodate the needs of nontraditional students, they will lose ground to other education and training service providers.

Recommendation 5(c): Allow for venue-neutral, modality-neutral assessment.

Under the traditional approach, assessment is tied to course completion. Postsecondary insti-tutions assert that this approach is essential to quality assurance. It also is easier to administer and provides institutions a basis for billable hours. But there is a bit of hubris involved. Namely, it implies that learning only takes place under the watchful eye of the faculty. Little effort is made to acknowledge learning that took place in other venues (e.g., on the job) or through other modalities (e.g., self-guided study). As a result, to earn a desired postsecondary credential, some students are required to take courses designed to impart knowledge, skills and abilities they already possess. This approach to assessment and credentialing adds to the costs borne by students and unnecessarily delays their efforts to parlay their knowledge, skills and abilities into employment and earnings.

Postsecondary institutions need to do more to acknowledge learning done elsewhere. To maintain quality assurance, the institutions should assess an individual's knowledge, skills and abilities before awarding credits and credentials. But assessment might be conducted apart from course completion. For example, let students "test out" of required courses if they can demonstrate a mastery of the subject matter at the same standards that apply to course completers. While this would reduce the institution's billable hours, some revenue could be generated by fees for alternative assessment and credentialing.

Thus far, our discussion has focused on the factors which make education and training providers slow to respond to rapidly changing KSA requirements for employment in high tech occupations. Employers need to fill critical jobs even if the current education and training system is not turning out precisely the kinds of workers they need. To fill those vacancies, employers somehow have to assess the available talent pool, pick the applicants with the most potential and provide them training on the job that imparts the precise knowledge, skills and abilities needed in the workplace.

V. What Criteria Can Employers Use When Scrambling to Fill Jobs So New and Unprecedented That Occupationally-Specific Programs Have Not Yet Been Developed to Meet Their Current KSA Requirements?

In the absence of certifications specifically based on demonstrated competencies in emerging technologies, prospective employers can only use **proxy** indicators in screening job applicants. When the curriculum does not address precisely the new technologies being deployed, employers can only look at job-seekers' education and training in closely related fields or disciplines which lay a strong foundation for acquiring highly technical skills.

Thus, educational attainment takes on increasing importance. Job requirements are rachetted ever upward as employers look at postsecondary credentials and field of study as proxy indicators of job-seekers' qualifications. Employers' use of these proxy indicators rests on the following assumptions:

- A postsecondary credential in **any** field of study signifies that the applicant has a general aptitude, the study habits and the self-discipline to master some body of knowledge that can be applied to the acquisition of new knowledge. Indeed, the knowledge content of the post-secondary credential earner's prior learning may be obsolete. What is not obsolete is the capacity to learn signified by the credential.
- More specifically, a job-seeker with a postsecondary credential in science, mathematics or engineering is believed to have a logical and precise mind-set, an ability to think critically and some mastery of the empirical approach to problem-solving. A credential-holder in math, science or engineering is presumed more capable of applying such habits of mind successfully in new situations.

  The particular problems encountered when an industry implements a new technology may well be novel and unprecedented. Regardless of the subject matter being studied, the empirical methods shared in common by mathematics, engineering and the sciences collectively constitute a prescription for problem solving even in novel situations: systematic observation, inductive theory building, deductive hypotheses generation, critical test design, precise measurement and systematic data collection, rigorous analysis and replication.

The Approach to Information Processing Taken in Math and Science is Critically Important to Workers Who Must Keep Up with Changing Technology

[M]athematics and sciences. . . have great explanatory power. . . The analytic tools of mathematics and the investigative skills of a scientific approach are also foundational skills for [the kind of] lifelong learning [required in the new knowledge economy]. . . [Math and science education] focuses on the skills of observation, information gathering, classifying, predicting, and testing. [Those who are trained in the sciences and mathematics are more likely to] try new possibilities, venture possible explanations, and follow them to their logical conclusions. . . to submit their work to questioning by others, to pull things apart and put them back together, and to reflect on how conclusions were reached.

Paraphrased from the Glenn Commission, *Before It's Too Late*, 2000

- Most technological developments (despite the ever accelerating pace of change) are incremental. That is, each successive change usually builds on prior technology. While each successive wave of technology may be smaller, faster, cheaper and more complex, the fundamental principles likely remain constant.

  A job-seeker with training in a closely related "old" technology is apt to understand the basic principles underlying each new iteration.

  Such job-seekers are presumed to: be familiar with sources of information about a particular genre of technology; embrace the habits of mind that keep them alert to changes; and possess the capacity to differentiate what is reliable, valid and useful in their specialty and closely related fields.

In short, educational achievement — particularly in a mathematics, science, engineering or a closely related technical field — suggest that the job-seeker has a more abundant store of transferable skills. Employers presume, therefore, that such job-seekers can be brought up to speed on each successive new technology faster than starting from scratch to educate and train a neophyte.

> See Katz, *op. cit.*; Autor, *op. cit.*; Bartel and Lichtenberg, *The Comparative Advantage of Educated Workers in Implementing New Technologies* in Review of Economics and Statistics vol. 69 (1987); Doms, et. al., *Workers, Wages and Technology* in Quarterly Journal of Economics vol. 112 (1997); A. Kruger, *How Computers Changed the Wage Structure* in Quarterly Journal of Economics vol. 108 (1993); and K. Murphy and F. Welch, *The Structure of Wages* in Quarterly Journal of Economics vol. 107 (1992).

The wage differentials that result from initial filtering tend to get wider over time. Those well-educated, technology-savvy workers who get the highest paying jobs in the first place are more likely to receive additional professional development as needed to stay in step with the rapid pace of technology change in their fields. Companies are more likely to invest in the continuing education of their managerial, professional and technical workers than in their front line workers.

Workers in industries subject to higher rates of technological change are more likely to receive more formal company training than workers in less technologically dynamic industries.

> (See for example, A. Kolstad and A. Sum, *Literacy in the Labor Force: Results from the National Adult Literacy Survey* (Washington, DC: National Center for Education Statistics, 1999); and Ann P. Bartel and Nachum Sicherman, *op. cit*.

There are several reasons why workers at the higher level of the occupational pyramid are more likely to receive formal company training.

- Turnover in high-skill positions is thought to be more detrimental to overall productivity.

  The local area network (LAN) manager in a medium size office, for example, helps keep other coworkers productive. If a LAN manager quits, other employees may lose or corrupt critical electronic files. It may take them longer to get answers from outside support on software problems, understand help-desk solutions and execute their instructions. They may miss out on timely productivity-enhancing hardware upgrades. The departure of a receptionist or janitor, on the other hand, would have a far less disruptive affect on a firm's other employees' productivity.

- It is more difficult to find replacements for high-skill occupations because persons with the requisite KSAs are in shorter supply. The disruptive effects on overall productivity are compounded the longer high-skill vacancies go unfilled.
- Conversely, most employers treat high turnover in low-skill positions as a fact of life. Most firms build coping techniques for high turnover at the low end of its staffing pattern into their business model.
  - Duties and tasks for jobs at the low end of the staffing pattern often are simplified, routinized, micro-managed and eventually automated.
  - Low-skill workers are recruited continuously. Employers, for example, may place standing job orders with the ES or constantly run classified ads for the low end positions to avail themselves constantly of a large pool of applicants.
  - New-hire orientation and short duties and task demonstrations are scheduled at frequent and regular intervals to handle the constant inflow of low skill workers in occupations subject to frequent turnover.
  - Firms may simply farm out positions at the low end of their staffing pattern to temporary help agencies or fill them with day laborers.

The Flip-Side: What Does This Mean From the Worker's Perspective?

There is no mystery to the higher earnings and employment resiliency of knowledgeable and technology-savvy workers. The more skills an individual brings to the workplace, the scarcer those skills are in the labor market at-large and the more critical they are to a firm's overall productivity, the more likely an employer is to: a) compensate an employee well enough to keep them from taking another job; and b) to make on-going investments in that employee to further upgrade their skills.

Recommendation 6: In the absence of occupationally-specific programs, students who aspire to careers in emerging, high tech fields should be advised to acquire solid foundation skills and knowledge in math, science, engineering and closely related technical fields. They also should be warned that technology is apt to render their KSAs obsolete. In accepting responsibility for their own long-term employability and financial security, they will have to engage actively in lifelong learning.

Recommendation 6 ultimately closes the loop. The main theme of this report has been that changing technology, shifting consumer demands, new human resource management practices, and other factors have a disruptive effect on employment demand. Using Schumpter's concept of *creative destruction*, we have shown how change is integral to a healthy economy. Outdated modes of production give way to more efficient modes. Along the way, new jobs are created while others are rendered obsolete. Because the labor market is not static, students and adult job-seekers must prepare constantly for change if they expect to enjoy the kind of employment resilience that can provide financial security and economic self-sufficiency in a volatile labor market. Thus, even as students or adult learners strive to acquire particular KSAs for tomorrow's job, they also must:

- acquire solid foundation skills that prepare them for future learning activities that more than likely will be required for those jobs that lay in store for them beyond the one for which they train initially; and
- adopt a proactive attitude about lifelong learning.

This report has offered a variety of recommendations to partner agencies and public officials for improving the capacity of the education, training, and workforce development system to respond quickly to the changing needs of the workplace. At best, however, policy makers can only provide students, adult learners and job-seekers with the opportunity to acquire the KSAs that employers demand in high wage occupations and the information they need to make rational choices. It is up to individuals to exercise personal responsibility in:

- using labor market data to make informed choices;
- taking advantage of learning opportunities throughout their worklife; and
- applying themselves diligently to both working and learning.

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Insightful analysis of resistence to change within organizations and its impact on productivity and competitiveness.

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APPENDIX I:
INTERNET-BASED RESOURCES

Disclaimer

Many of the websites in this appendix represent private entities which offer information to subscribers and/or offer to do research for a fee. By listing such sites in this Appendix, the CDR is not endorsing any private entity nor is the CDR recommending that readers subscribe to or engage the services of the website hosts. In fact, all of the information and data gathered for this report were obtained for free. Often sites offering to do in-depth research or more detailed data gathering provide general news items, background information and raw data at the front end of the website before requiring subscribers to log-in to for-fee services.

Grants and Capacity-Building Resources

Alfred P. Sloan Foundation . . . . http://www.sloan.org/

American Association for the Advancement of Science Funding Alert Service . . . . http://www.grantsnet.org/

Apple Computer: http://www.apple.com/education/k12/leadership/

Bill and Melinda Gates Foundation . . . . http://gatesfoundation.org/

Camille and Henry Dreyfus Foundation, Inc. (chemical and environmental sciences) . . . . http://wwwdrefus.org/

Cisco Foundation: http://cisco.com/warp/public/779/edu/

Community Technical Centers Network . . . . http://www.ctcnet.org/

Educause National Learning Infrastructure Initiative . . . . http://www.educause.edu/nlii/

Federal Communications Commission . . . . http://www.fcc.gov/learnet/
information on “e-rate” (assistance and incentives to improve access to advanced services for schools, libraries and health care facilities - especially in impoverished rural or inner city areas)

Ford Foundation . . . . http://fordfound.org/

IBM corporate philanthropy: . . . . http://www/ibm.com/ibm/IBMGives/grantfaq/htm/

Intel Corp.: . . . . http://intel.com/

MCI World: . . . . http://wcom.com/marcopolo/
and partner in Edvancenet.org . . . . http://www.edvancenet.org/

National Foundation for the Improvement of Education . . . . http://www.NFIE.org/

National Institutes of Health . . . . http://grants.nih.gov/
National Human Genome Research Institute . . . . http://www.nhgri.nih.gov/
special set asides for funding training programs for females and minorities for technical jobs impacted by the Human Genome Project
National Institute of Environmental Health Sciences . . . . http://niehs.nih.gov/external/scirsrch.htm
See especially Worker Education and Training Program and Environmental Genome Project

National Science Foundation (NSF) . . . . **http://www.nsf.gov/**

See especially NSF funding opportunities for science, mathematics, engineering and technology at the undergraduate level . . . . http://www.ehr.nsf.gov/ehr/due/links/other_programs.asp/

Custom-build your own NSF funding-alert newsletter . . . . http://www.nsf.gov/home/cns/start.htm/

National Urban Technology Center (also in Spanish) . . . . http://www.urbantech.org/

Navigation Resources for Rural Schools . . . . http://nces.ed.gov/surveys/ruraled/

North Central Regional Education Laboratory "Pulling Together" R&D Resources for Rural Schools . . . . http://www.ncrel.org/rural/

PowerUP . . . . http://powerup.org/

Rand Corporation

- Research and Development in the United States (RADIUS) . . . . http://www.rand.org/scitech/radius/
- Science and Technology Policy Institute . . . . http://www.rand.org/centers/stpi/
- State-by-state break down of federal R&D http://www.rand.org/publications/MR/MR1194/
  - Texas listings http://www.rand.org/publications/MR/MR1194/MR1194.chapter45.pdf

Small Business Innovation Research Program . . . . http://www.sbaonline.sba.gov/sbir/sbir.html/

Cooperative set asides for small businesses available through the Department of Defense, National Institutes of Health's Office of Extramural Research, National Aeronautics and Space Administration; Department of Energy; National Science Foundation; Department of Agriculture; Department of Education; Environmental Protection Agency's National Center for Environmental Research *Science to Achieve Results* program; Department of Transportation; and the Department of Health and Human Services.

Science Magazine's Next Wave Funding Alert . . . . http://nextwave.sciencemag.org/awards.dtl/

Technology Infrastructure Fund Board (Texas) . . . . http://www.tifb.state.tx.us/

Texas Department of Economic Development . . . . http://www.tded.state.tx.us/

- Border Initiatives . . . . http://www.tded.state.tx.us/borderinitiatves?
- Infrastructure . . . . http://www.tded.state/tx.us/texascapitalfund/tcf-infr.htm/
- Small Business Initiatives . . . . http:/www.tded.state.tx.us/smallbusiness/
- Smart Jobs . . . . http//.www.tded.state.tx.us/smartjobs/

Texas Education Agency Technology Division . . . . http://www.tea.state.tx.us/technology/

U.S. Department of Agriculture

- National Rural Development Partnerships . . . . http://www.rurdev.usda.gov/
  - Business-Cooperative Programs . . . . http://www.rurdev.usda.gov/rbs/
  - Business Programs . . . . http://www.rurdev.usda.gov/bp/
- Rural Economic Area Partnership Initiative . . . . http://www.rurdev.usda.gov/ocd/reap.html/

U.S. Department of Commerce Technology Administration

Economic Development Administration . . . . http://www.doc.gov/eda/

National Institute of Standards and Technology

Advanced Technology Program . . . . http://atp.nist.gov/

National Telecommunications and Information Administration

Technology Opportunities Program (TOP - formerly known as the Telecommunications and Information Infrastructure Assistance Program or TIIAP) . . . . **http://www.nita.doc.gov/otiahome/top/**

U.S. Department of Education

Education Resource Organization Directory . . . . http://www.ed.gov/programs/erod/

Fund for the Improvement of Postsecondary Education . . . . http://www.ed.gov/offices/OPE/FIPSE/

Technology Grants . . . . http://www.ed.gov/technology/edgrants.html

includes grants for infrastructure and to assist professional development of teachers to help them master and apply information technology in the classroom.

U.S. Department of Health's Health Resources and Service Administration . . . . http://www.hrsa.gov/

Training grants and scholarships to needy students to improve diversity in the health sciences

See also state profile for Texas http://stateprofiles.hrsa.gov/1999/TX199901.htm/

US Department of Labor (H-1B Technical Skills Training Grant Program) . . . . http://wdsc.doleta.gov/

DoL grants are cross-posted in the on-line Federal Register http:www.access.gpo.gov/su_docs/fedreg/

and at . . . . http://www.usworkforce.org/

W.K. Kellogg Foundation

Engaging Latino Communities for Education (ENLACE)

. . . . http://www.wkkf.org/Programming Interests/YthEdHighEd/Enlace/default.html/

Managing Information with Rural America (MIRA)

. . . . http://www.wkkf.org/Programming Interests/FoodRur/MIRA/default.html/

Curriculum Initiatives, Teacher Resources and Standards

21st Century Workforce Commission (e-handbook of best practices)

. . . . . http:..www.workforce21.org/best_practices/

Accreditation Board for Engineering and Technology . . . . http://www.abet.og/

Computing Accreditation Commission . . . . http://www.abet.org/cac/cac.htm/

Engineering Accreditation Commission . . . . http://www.abet.org/eac/eac.htm/

Related-Engineering Accreditation Commission . . . . http://www.abet.org/rac/rac.htm/

Student and Parents' Guide to Selecting an Engineering Program . . . . . http://www.abet.org/abet_faq.htm/

Technology Accreditation Commission . . . . http://www.abet.org/tac/tac.htm/

Alabama Supercomputing Program to Inspire Computational Research in Education

(teachers' professional development) . . . . http://www.aspire.cs.uah.edu/aspire/

American Association of Community Colleges and National Center for Higher Education

Working Connections . . . . http://www.aacc.nche.edu/initiatives/connections/resources.htm/

Arizona Department of Education . . . . http://www.ade.state.az.us/standards/technology/

American Association for the Advancement of Science http://www.project2061.org/

(Includes: Science for All Americans On-Line, Benchmarks On-Line; Blueprints On-Line, and Evaluations of Science and Mathematics Textbooks On-Line)

American Mathematical Society . . . . http://www.ams.org/

Association for Computing Machinery in collaboration with the Institute for Electrical and Electronic Engineers' *Computing Curricula 2001* http://www.acm.org/sigcse.cc2001/

Bayer Corporation (Making Science Make Sense & Science Library) . . . . http://www.bayerus.com/

Brainbench . . . . http://www.brainbench.com/

CESAME (programs for students and teachers) . . . . http://www.dac.neu.edu/cesame/

Chauncey Group . . . . http://www.chauncey.com/

Cisco Networking Academy http://www.cisco.com/warp/public/779/edu/

Computer Associates (modular/granular approach) http://www3.ca.com/education/paths.htm/

Computer Science Accreditation Board . . . . http://www.csab.org/
CSAB accredited programs in Texas . . . . http://abet.org/acrsch.htm#texas

Computing Technology Industry Association . . . . http://comptia.org/

Corporate University Xchange . . . . http://www.corpu.com/

Curriculum Administrator (e-periodical) . . . . http://www.educatorsportal.com/

Dallas Computer Literacy Program http://www.mach2media.com/DCLP/

Education Commission of the States . . . . http://www.ecs.org/

Education Development Center, Inc.
Educator's Website for Information Technology . . . . http://www.edc.org/EWIT/curr.htm/

Eisenhower National Clearinghouse . . . . http://www.enc.org/

European Physical Society's PhysNet . . . . http://www.eps.org/physnet/education.htm/

For Inspiration and Recognition of Science and Technology . . . . http://www.usfirst.org/

Forrester Research (e-business surveys) . . . . http://forrester.com/

Georgetown University Visible Learning Project . . . . http://crossroads.georgetown.edu/vlp/

Industry Training Credit Approval Process . . . . http://www.itcap.com/

Institute for Certification of Computing Professionals . . . . http://www.iccp.org/

International Society for Technology in Education (National Educational Technology Standards) . . . . http://cnets.org/intro_splash.htm/

Massachusetts Institute of Technology Sloan School of Management e-business seminars . . http://www.sloan.edu/

MicroSoft Authorized Academic Training Program . . . . http://www.microsoft.com/aatp/

National Academic Foundation . . . . http://www.naf-education.org/

National Academy of Science
Career Planning Center for Beginning Scientists and Engineers http://ww2.nas.edu/cpc/

National Advisory Coalition for Telecommunications Education and Learning . . . . http://www.nactel.org/

National Aeronautics and Space Administration
Awareness . . . . http://www.nasa.gov/kids.html/
Educational Programs . . . . http:/educcation.nasa.gov/

National Assessment Governing Board . . . . http://nagb.org/naep/

National Council of Teachers of Mathematics Electronic Principles and Standards . . . . . http://standards.nctm.org/

National Institute on Science Education (federally-funded at U. of Wisc.) . . . . . http://www.wcer.wisc.educ/NISE/

National Occupational Competency Testing Institute . . . . http://www.nocti.org/

National Research Council Committee on National Science Education Standards
. . . . . http://www.nationalacademies.org/nrc/

National Science Teachers' Association . . . . http://www.sciLINKS/

National Skills Standards Board . . . . http://www.nssb.org/main.cfm/

Nortel Networks NetKnowledge . . . . http://www.nortelnetworks.com/solutions/education/netknowledge/

Northeast Center for Telecommunication Technologies . . . . http://www.nctt.org/

Northwest Center for Emerging Technologies (Bellvue Community College - WA)
. . . . . http://www.nwcet.org/educators/itskills.htm/

Novell . . . . http://education.novell.com/neapinfo/

Ohio, State of (Board of Regents and State Board of Education) . . . . http://itWORKS-Ohio.org/

Oracle University . . . . http://education.oracle.com/

OpNet (internships for Calif. high school students in IT) . . . . http://www.opnetwork.org/

Popular Science Learning Lab . . . . http://www.popsci.iln.net/

Regional Educational Laboratories (federally-funded national network for research on best practices)
Appalachian Educational Laboratory (specializing in educational technology) . . . . http://www.ael.org/
(Mid-Atlantic) Laboratory for Student Success (at Temple University) . . . . . . http://www.temple.edu/lss/
Midcontinent Regional Educational Laboratory (standards-based education) . . . . . . http://www.mcrel.org/

North Central Regional Educational Laboratory . . . http//www.ncrel.org/enguage/skills/skills.htm/
See also NCREL on Computer-Based Technology Usage and Expectations Surveys, Curriculum mapping tools, EdSTAR, Technology implementation handbook and Teachers' Guide, Teacher Professional Development in Technology
Northeast & Islands Regional Education Laboratory (at Brown University) . . . http://www.lab.brown.edu/
Northwestern Educational Regional Laboratory (re-engineering schools) . . . . http://www.nwrel.org/
Pacific Resources for Education and Learning (reading & language curriculum) . . . . http://www.prel.org/
Southwestern Educational Development Laboratory (serves Texas) . . . . http://www.sedl.org/
WestEd (educational assessment) . . . . http://www.wested.org/

Silicon Valley Manufacturing Group (paid summer internships for teachers in IT firms)
. . . . http://www.svmg.org/

Southern Methodist University Advanced Computer Education Center
. . . . http://www.seas.smu.edu/netech/

Teacher's Professional Development in Information Technology (MCI World & others)
. . . . http://wcom.com/marcopolo/

Teachers Teaching with Technology http://www.t3ww.org/t3/index.html/

Technology and Learning Magazine (e-periodical) http://www.techlearning.com/index1.html/

Technology Workforce Coalition . . . . http://www.techcoalition.org/

Texas Instruments (K-12 Math and Science Initiatives)
. . . . . http://www.ti.com/corp/docs/community/k-12-3.htm/

Thomas B. Fordham Foundation . . . . http://www.edexcellence.net/standards/

University of Texas - Austin
Dana Center (TEXTEAMS) . . . . http://utdanacenter.org/
Innovative Creative Capital (IC2) Institute EnterTech Project . . http://www.utexas.edu/depts/ic2/et/

U.S. Department of Commerce Technology Administration http://www.go4it.gov/

U.S. Department of the Interior
U.S. Geological Survey materials for teachers and students . . . http://www.usgs.gov/tracks/teachers.html/
also operates Ask-a-Geologist care of *ask-a-geologist@usgs.gov*

Wisconsin Department of Public Instruction . . . . http://www.dpi.state.wi.us.dpi/standards/

World Organization of Webmasters . . . . http://www.joinwow.org/certification_index.html/

Youth Tech Entrepreneurs . . . . http://www.yte.org/

Zona Land . . . . http://id.mind.net/~zona/

Public Policy, Research and Information

21st Century Workforce Commission http://www.workforce21.org/

Accreditation Board for Engineering and Technology . . . . http://www.abet.og/
Computing Accreditation Commission . . . . http://www.abet.org/cac/cac.htm/
Engineering Accreditation Commission . . . . http://www.abet.org/eac/eac.htm/
Related-Engineering Accreditation Commission . . . . http://www.abet.org/rac/rac.htm/
Student and Parents' Guide to Selecting an Engineering Program . . . . . http://www.abet.org/abet_faq.htm/
Technology Accreditation Commission . . . . http://www.abet.org/tac/tac.htm/

Alfred P. Sloan Foundation . . . . http://www.sloan.org/programs/edu_careers.htm/

American Association of University Women . . . . http://www.aauw.org/

American Association for the Advancement of Science . . . . http://www.aaas.org/education/
AAAS Committee on Science, Technology and Congress
. . . . http://www.aaas.org/spp/dspp/cstc/cstc.html
Directorate for Science and Policy Programs . . . . http://www.aaas.org/ssp/

American Council on Education . . . . http://www.acenet.edu/

American Economic Association . . . . http://www.vanderbilt.edu/AEA/

American Electronics Association
Industry Statistics and Research . . . . http://www.aeanet.org/public/research.html/
Small Business CyberCenter . . . . http://www.aeanet.org/public/small_bus/small_bus.asp/

American Federation of Teachers . . . . http://www.aft.org/edissues/index.htm/

American Federation of Labor/Congress of Industrial Organizations (AFL-CIO) . . . . http://www.aflcio.org/

American Institute of Certified Public Accountants . . . . http://www.aicpa.org/

American Youth Policy Council . . . . http://www.aypc.org/

Arbortex (XLM scenarios) . . . . http://www.arbor-text.com/think_tank

Arthur Andersen . . . . http://www.andersen.com/
See especially investor services such as industry developments in health care/pharmaceuticals, manufacturing, and technology sector.

Aspen Institute Policy Programs . . . . http://www.aspeninst.org/
Rural Development and Community Foundations Initiative . . http://www.aspeninst.org/csg/csg.rdcf.htm/

Association for Career and Technology Education . . . . http://www.avaonline.org/
(Formerly the American Vocational Association.)

Association of University Technology Managers
annual survey of university patents and royalties . . . . http://www.autm.net

Bayer Corporation (NSF-collaborative research) . . . . http://www.bayerus.com/

Benton Foundation (under-served communities) . . . . http://www.digitaldividenetwork,org/

Better Business Bureau Code of Online Business Practices . . . . http://bbbonline.org/code/index.asp/

Brookings Institution . . . . http://www.brook.edu/

Brown University
- Annenberg Institute on Education . . . . http://www.annenberginstitute.org/
- Futures Project on Higher Education . . . . http://www.futuresproject.org/

Campus Computing Project . . . . http://www.campuscomputing.net/

CATO Institute technology and telecommunications issues unit . . . . http://www.cato.org/tech/index.htm/

Carnegie Mellon University
- College of Engineering . . . . http://www.cit.cmu.edu/
- Computer Science . . . . http://www.csci.cmu.edu/
- Engineering and Public Policy . . . . http://www.epp.cmu.edu/

CFO Publishing . . . . http://www.cfo.com/

Center for the New West (impact of information technology on small business and rural/remote communities) . . . . http://www.newwest.org/

Center for the Public Domain (Red Hat Institute) . . . . http://www.centerforthepublicdomain.org/

Center for the Study of Technology and Society . . . . http://www.tecsoc.org/

Central Intelligence Agency
- Office of the Director of Central Intelligence . . . . http://www.odci.gov/
- **National Intelligence Council . . . . http://www.odci.gov/nic/**

Centre for the Exploitation of Science and Technology . . . . http://wwwcest.org.uk/

CEO Forum . . . . http://www.ceoforum.org/

CNET Networks (CNET News.Com) . . . . http://new.cnet.com/

Computing Research Associates . . . . http://www.cra.org/

Computer Science Accreditation Board . . . . http://www.csab.org/
- CSAB accredited programs in Texas . . . . http://abet.org/acrsch.htm#texas

Computing Technology Industry Association . . . . http://www.comptia.org/

Converge (online magazine) . . . . http://www.converge.com/

Corporate Capital Formation, Inc. . . . . http://www.ccf-inc/

Council for Excellence in Government . . . . http://www.exelgov.org/
Intergovernmental Technology Leadership Consortium . . . . http://www.excelgov.org/techcon/index.htm/

Council of Chief State School Officers . . . . http://www.ccsso.org/

Council on Policy Research in Education
. . . . http://www.wcer.wisc.edu/cpre/teachercomp/reform/nbtpspay.htm/

Cybergeography . . . . http://www.cybergeography.org/
Atlas of Cyber Space . . . . http://www.cybergeography.org/atlas/atlas.com/

Dataquest http://www3.gartner.com/

Deloittte and Touche . . . . http://delloitte.com/
Data gathering and analysis, investor intelligence services including industry watch, business location decsions, mergers and acquisitions, intangible assets and human capital management

Digital Future Coalition . . . . http://www.dfc.org/

Ernst and Young . . . . http://www.ey.com/
Data gathering and analysis, investor intelligence services include Center for Business Innovation, Center for Industry Technology Innovation, eRisk and Computer Forensic Services
See innovation reviews . . . . http://www.businessinnovation.ey.com/cgi-bin/pubs/pubs.plx?sort=topic/

Economic Policy Institute . . . . http://www..epinet.org/
particularly involved in studies of government policy on wage differentials

Economics of Innovation and New Technology (journal) http://www.gbhab.com/journals/376/376-top.htm/

Economist magazine Science section international digest . . . . http://economist.com/science/index.cfm.

Educause . . . . http://www.educause.org/
***Edcom Review* (e-periodical) . . . . http://www.educause.edu/pub/er/erm.html/**

Educational Development Corporation
Women's Educational Equity Act Resource Center . . . . http://www.edc.org/womensequity

Educational Resource Information Center (Ask ERIC maintained by Syracuse University)
. . . . . http://ericir.syr.edu/eric/

eMARKETER . . . . http://www.emarketer.com/

Epoch Partners . . . . http://www.epoch.com/index.html/

Executive Office of the President
Office of Management and Budget . . . . http://www.whitehouse.gov/omb/
See especially regulations and guidelines governing government data collection activities under the Government Performance and Results Act (GPRA) and federal manpower needs assessment - particularly for IT workers in the coming wake of the Baby Boom retirement bulge.

Office of Science and Technology Policy . . . . http://www.ostp.gov/
National Science and Technology Council . . . . http://www.ostp.gov/NSTC/html.nstc-an.html
President's Commission on Critical Infrastructure Protection
Critical Infrastructure Assurance Office . . . . http://www.ciao.gov/
President's Committee of Advisors on Science and Technology
. . . . http://www.ostp.gov/nstc/html/pcast.html/

Exodus (web performance and management white papers) . . . . http://www.exodux.net/

Fast Company (e-periodical) . . . . http://www.fastcompany.com/

Federal Communications Commission . . . . http://www.fcc/gov
use site map to locate policy and development assistance for wireless communications, broadband access, common carriers (telephony), consumer protection, international trade and telecommunications policy. See especially selected sites below
3rd Generation Wireless http://www.fcc.gov/3g/
Broadband . . . . http://www.fcc.gov/broadband/
Office of Engineering and Technology . . . . http://www.fcc.gov/oet/

Federal Reserve Board . . . . http://www.federalreserve.gov
National Survey of Small Business Finance . . . . http://www.federalreserve.gov/boarddocs/surveys/
Staff studies and working papers . . . . http://www.federalreserve.gov/staffpubs/staffstudies/
Federal Reserve - Dallas . . . . http://www.dallasfed.org/
***Southwest Economy* (Dallas Fed briefings) . . . . http://www.dallasfed.org/htm/pubs/swe.htm/**
Federal Reserve - New York City (see staff reports) . . . . http://www.ny.frb.org/

Federal Trade Commission . . . . http://www.ftc.gov/index.html/
topical index on anti-trust, consumer protection and economic impact of trade organized by industry

Food and Drug Administration . . . . http://www.fda.gov/
Center for Biologics Evaluation and Research . . . . http://www.fda.gov/cber/
Center for Food Safety and Nutrition . . . . http://vm.cfsan.fda.gov/
Biotechnical Research . . . . http://www.cfsan.fda.gov/~lrd/biotechm.html/
Center for Devices and Radiological Health . . . . http://www.fda.gov/radhealth/
Center for Drug Evaluation and Research . . . . http://www.fda.gov/cder/
Provides option to subscribe to alerts and newsletter
Center for Veterinary Medicine . . . . http://www.fda.gov/cvm/
Bioengineering of plants and animals
. . . . http://www.fda.gov/cvm/biothechnology/bioengineered.html/

George Washington University Cyberspace Policy Institute . . . . http://www.cpi.seas.gwu.edu/

Harvard Business School (Working Knowledge) . . . . http://hbsworkingknowledge.hbs.edu/

Hoover's Online Business Services . . . . http://www.hoover.com/
Subscriber services include intelligence monitoring, company profiling, IPO watch and small business start-up advice.

Hudson Institute . . . . http://www.hudson.org/

Human Resource Development Canada . . . . http://www.hrdc.drhc.gc.ca/

Industrie Canada . . . . http://strategis.ic.gc.ca/

Information Technology Association of America . . . . http://www.ita.org/workforce/studies/

Infoworld . . . . http://www.infoworld.com/

Initiative for a Competitive Inner City (Harvard Professor Michael Porter in collaboration with *Inc. Magazine* and Price Waterhouse . . . . **http://ccc.icic.org/**
Includes ***Inner City 100*** (recognition of America's top 100 firms locating headquarters or more than 51% of their operations in inner cities); ***Inner-City Workforce Program*** (dissemination of best practices in recruiting and training under-employed inner-city residents); ***Cluster Mapping Project,*** Inner-city definitions and Zip code database; and ***State of the Inner-City*** indexing initiative.

Institute for the Future . . . . http://www.iftf.org/

Institute for Operations Research and Management Sciences . . . . http://www.inform.org/

Institute for Women in Trades, Technology and Science . . . . http://www.iwitts.com/

Institute of Electrical And Electronic Engineers . . . . http://ieee.org/
IEEE Society on the Social Implications of Technology
. . . . http://www4.ncsu.edu/unity/users/j/jherkert/index.html/
IEEE Mentoring Guide . . . . http://ieee.org/organizations/committee/women/wiement.htm/

Institute of Medicine . . . . http://www.iom.edu/

Internal Revenue Service (Small Business Start-Up Corner and Investment Tax Credit)
. . . . http://www.irs.ustres.gov/prod/bus_info/sm_bus/index.html/

International Data Corporation . . . . http://idc.com/

Internet Patent News . . . . http://www.bustpatent.com/

Internet Policy Institute . . . . http://www.internetpolicy.org/index.html/
Research Directory . . . . http://www.internetpolicy.org/research/directory.html/

iSquare (Doing Business with Government) . . . . http://www.isquare.com/

Journal of Product Innovation Management . . . . http://www-east.elsevier.com/pim/menu.html/

Journal of Engineering and Technology Management . . . . http://www.elsevier.com/inca/publications/

Jupiter Media Matrix . . . . http://www.jmm.com/

Just for the Kids (Texas Best Practices Research) http://www.just4kids.org/

KPGM . . . . http://www.kpgm.com/
Industry overviews and forecasts, eFraud, intellectual properties

Keynote (Internet Performance Authority) . . . . http://www.keynote.com

Library of Congress . . . . http://thomas.loc.gov/
Public Laws, pending legislation, Congressional Directory, Committee Reports, roll call votes and *Congressional Record* on line.

Massachusetts Institute of Technology
Sloan School of Management e-commerce research . . . . http://ecomerce.mit.edu/
***Technology Review* magazine . . . . http://www.techreview.com**

Matrix Information and Demographic Services . . . . http://www.matrix.net/

Meckler Media (internet.com) . . . . http://mecklermedia.com/home-d.html/
Application Service Provider listings . . . . http://asp.thelist.com/
e-Commerce News . . . . http://www.internetnews.com/ec-news/
IT Management http://itmanagement.earthweb.com/
International Internet . . . . http://www.internet.com/sections/international.html/
Internet Counter . . . . http://www.thecounter.com/
Internet Investing . . . . http://www.internet.com/sections/stocks.html/
Internet Product Watch . . . . http://ipw.internet.com/
Internet Service Provider List . . . . http://www.thelist.com/
Wireless News . . . . http://wireless.internet.com/

Merrill Lynch (research and technology stock reporting) . . . . http://www.ml.com/

Milken Institute . . . . http://www.milken-inst.org/

Moody's Investor Service (research unit) . . . . http://www.moodys.com/

Morgan Stanley Dean Witter (research unit) . . . . . . http://www.morganstanley.com/techresearch/info/html/

Motley Fool . . . . http://www.fool.com/

Multimedia Super Corridor Research and Development (Malaysia) . . . . http://www.mdc.com.my/

National Academy of Engineering . . . . http://www.nae.edu/nae/

National Academy of Science . . . . http://www4.nas.edu/.

National Alliance for Business . . . . http://www.nab.com/

National Assessment Governing Board . . . . http://nagb.org/naep/

National Association of State Development Agencies . . . . http://www.nasda.com/

National Bureau of Economic Research (non-profit) . . . . http://nber.org/
Development of the American Economy . . . . http://nber.org/programs/dae/
Economics of Education . . . . http://nber.org/programs/educ/
Labor Studies . . . . http://nber.org/papersbyprogram/ls.html/
Productivity . . . . http://nber.org/papersbyprogram/pr.html/

National Center for Career and Technical Education
Information dissemination from Ohio State University . . . . http://www.nccte.com/
Research unit at hosted by University of Minnesota . . . . http://www.nccte.com/

National Center for Higher Education Management Systems . . . . http://www.nchems.org/

National Center for Research in Vocational Education (NCRVE) . . . . http://vocserve.berkeley.edu/
Archives for publications and research from 1988-1999; thereafter see National Center for Career and Technical Education

National Center for Technology in Education (Ireland) . . . . http://www.ncte.ie/

National Council of Teachers of Mathematics . . . . http://www.nctm.org/

National Council on Entrepreneurship . . . . http://www.ncoe.org/

National Education Association (technology issues) . . . . http://www.nea.org/cet/index_policy.html/

National Exchange Carriers' Association . . . . http://www.neca.org/
Analysis of the Telecommunications Act of 1996 provisions to make rural rates reasonably comparable to urban prices and services.

National Governors' Association . . . . http://www.nga.org/

National Research Council (Canada) . . . . http://scitech.gc.ca/

National Research Council (U.S.) . . . . http://www.nationalacademies.org/nrc/

National Retail Federation (e-tailing statistics) . . . . http://www.shop.org/research/default.htm/

National Science Teachers' Association . . . . http://www.nsta.org/

National Science Foundation http://www.nsf.gov/
See especially Science Resource Studies . . . . http://www.nsf.gov/sbes/srs/
Science and Engineering Indicators . . . . http://www.nsf.gov/sbes/srs/stats.htm/
National Science Board . . . . http://nsf.gov/nsb/

National Urban League . . . . http://www.nul.org/

National Venture Capital Association . . . . http://www.nvca.org/

New York University
Taub Urban Research Center . . . . http://urban.nyu.edu/
Urban Research Initiative . . . . http://www.informationcity.org/researc/
gallery of Internet maps . . . . http://www.informationcity.org/research/gallery/index.htm/

Northwest Center for Emerging Technologies (Bellvue Community College - WA)
. . . . http://www.nwcet.bcc.ctc.edu/main.asp/

Nua (Internet Survey Digest Service) . . . . http://www.nua.ie/surveys/

Nuclear Regulatory Commission . . . . http://www.nrc.gov/

Oklahoma University Science and Public Policy Program . . . . http://www.ou.edu/spp/

Office of Personnel Management .... **http://www.opm.gov/studies/index.htm/**

See special studies on manpower needs in the federal civil service with guides to the OPM's methods for identifying occupational KSA requirements.

Office of the President of the United States IT strategic planning resources

High Performance Computing and Communications .... http://www.hpcc.gov/

(Includes Interagency Work Group on Information Technology Research and Development that coordinates federal IT R&D; President's Advisory Committee on Information Technology; Next Generation Internet Initiative; and National Coordinating Office for Computing, Information and Communications)

Office of Science and Technology Policy

.... http://www.whitehouse.gov/WH/OSTP/html/OSTP_Home.html/

Pew Charitable Trusts .... http://pewtrusts.com/

Policy Research in Engineering, Science and Technology .... http://les.man.ac.uk/PREST/

Postsecondary Education Opportunity .... **http://www.postsecondary.org.**

Price, Waterhouse, Coopers .... http://pwc.global.com/

Industry overviews and forecasts

Progress and Freedom Foundation .... http://www.pff.org/

Progressive Policy Institute .... **http://www.neweconomyindex.org/**

U.S. Compared to other nations on indicators ... **http://www.neweconomyindex.org/index_nei.html/**

State level indicators .... **http://www.neweconomyindex.org/state/index.html/**

Indicators for top 50 high technology metropolitan areas in the US

.... **http://www.neweconomyindex.ogr/metro/index.html/**

Public Agenda Online .... http://www.publicagenda.org/

Public Broadcasting System

Classroom Initiatives: http://www.pbs.org/digitaldivide/class-mail.html/

Gender and the Digital Divide: .... **http://www.pbs.org/digitaldivide/gender-mail.html/**

Outreach Activities: .... http://www.pbs.org/digitaldivide/news.html/

Race and the Digital Divide: **http://www.pbs.org/digitaldivide/race-mail.html/**

SCANS 2000 Project (Ready to Earn) .... http://www.pbs.org/als/rte/

PurpleSquirrle .... http://www.purplesquirrle.com/

Red Herring Magazine .... http://www.redherring.com/

Rural Policy Research Institute .... http://www.rupri.org/

Consortium partners Iowa State University, University of Nebraska and University of Missouri

Salary.com .... http://salary.com/salarywizard/

This search engine finds prevailing salaries by location and occupation. Other search engines have been constructed using the same logic and front end to look at salaries in occupational specialties (e.g., Accounting or Programming) or by level (e.g., entry-level jobs in a specified industry.

Science* magazine's *Technology Quarterly .... **http://www.science/tq/index.cfm/**

Scientific American **. . . . . http://www.sciam.com/**

Search Engine Watch . . . . http://searchenginewatch.com/

Securities and Exchange Commission . . . . http://www.sec/info.com/
See **EDGAR** archives (Electronic Data Gathering, Analysis and Retrieval
system of the SEC contains corporate filings back to 1993 . . . . . **http://www.sec.gov'cgi-bin/srch-edgar/**

Sematech . . . . http://www.sematech.org/public/home/htm/

Silicon Valley @Work (The Working Partnership) . . . . http://www.atwork.org/
one of the few sites devoted largely to organized labor (AFL-CIO affiliate organization) views
on the impacts of information technology, the contingency workforce and working conditions

Small Business Administration
Historically Underutilized Businesses . . . . http://www.sba.gov/outreach/histunderutilbus/
Small Business Innovation Research Program . . . . http://www.sbaonline.sba.gov/sbir/sbir.html/
SBIR Stats by State . . . . http://www.sba.gov/advo/stats/
SBIR rankings http://www.sba.gov/sbir/98sbirrank.html/
Small Business Start-Up . . . . http://www.sbaonline.sba.gov/starting/financing
Small Business Technology Transfer Program . . . . . . http://www.sbaonline.sba.gov/sbir/sttrq.html/

Social Science Research Network . . . . http://www.ssrn.com/
Economics Research Network . . . . http://www.ssrn.com/ern/index.html/

Society of Manufacturing Engineers . . . . http://www.sme.org/

Software Information Industry Association . . . . http://www.siia.net/

Software Publishers' Association . . . . http://www.spa.org/

Southern Growth Policies Board . . . . http://www.southern.org/pubs/clearinghouse

Standard and Poor's (research unit and school district evaluation service) . . . . http://www.standardpoor.com/

Statistics Canada . . . . http://stats.can.ca/

Storage Networking Industry Association . . . . http://www.snia.org/

Tech Week (e-magazine) . . . . http://www.techweek.com/articles/

Technology Horizons in Education (e-periodical) . . . . http://www.thejournal.com/magazine/

Technology Workforce Coalition . . . . http://www.techcoalition.org/

Techweb.Com . . . . http://techweb.com/encyclopedia/

Telegeography . . . . http://www.telegeography.com/

Tennessee Valley Authority (TVA) and the University of Kentucky . . . . http:/www.rural.org/

Texas Business and Education Coalition . . . . http://www.tbec.org/

Texas Comptroller of Public Accounts . . . . http://www.window.state.tx.us/

e-Texas (recommendations for smaller, smarter, faster government)
. . . . **http://www.e-texas.org/recommend/**

Texas Education Agency Technology Division . . . . **http://www.tea.state.tx.us/technology/**

Texas Workforce Commission
Career Development Resources . . . . **http://www.cdr.state.tx.us/**
See especially DECIDE, OSCAR, SOCRATES, monographs and publications
Labor Market Information Division . . . . **http://www.twc.state.tx.us/lmi/**
See especially TRACER

Thomas B. Fordham Foundation . . . . http://www.edexcellence.net/

Training Magazine (e-magazine) . . . . http://www.trainingsupersite.com/

U.S. Department of Agriculture
Economic Research Service . . . . http://www.ers.usda.gov/
Data and County Codes . . . . **http://www.ers.usda.gov/briefing/rural/data/index.htm/**
(Included County Topology Codes, Urban-Rural Commuting Area Codes with Commuting Zone and Labor Market Area Codes, Rural-Urban Continuum Code, Urban Influence Code, Natural Amenities Index plus documentation of federal fund expenditures for all agencies by county.)
Issues in Rural Manufacturing . . . . http://www.ers.usda.ers.gov/epubs/
Rural Information Center . . . . http://www.nal.usda.gov/ric/

U.S. Department of Commerce . . . . **http://www.digitaldivide.gov/**
Bureau of Economic Analysis . . . . **http://www.bea.doc.gov/**
Industry Economics Division **http://www.bea.doc.gov/bea/dn2.htm/**
Bureau of Export Administration (hi tech export policy) . . . . . . http://www.bxa.doc.gov/hpcs/default.htm/
Census Bureau . . . . **http://www.census.gov/**
Center for Economic Studies . . . . **http://www.ces.census.gov/ces.php/papers/**
Current Population Survey (jointly conducted with Bureau of Labor Statistics)
Income and Poverty data . . . . **http://www.bls.census.gov/cps/cpsmain.htm/**
Data Extraction Service . . . . **http://www.census.gov/ftp/pub/des/**
Economic Activities . . . . **http://www.census.gov/epcd/**
Census Economic Briefing Room . . . . **http://www.census.gov/cgi-bin/briefingroom/briefrm/**

Resources from Census Bureau
Manufacturing Surveys: Annual Survey of Manufacturers; Current Industrial Reports; Manufactures Shipments, Inventories and Unfilled Orders
Services Surveys: Annual Trade Survey (wholesale); Wholesale Trade Monthly; Annual Retail Trade Survey; Retail Trade Monthly; Transportation Annual Survey; Service Annual Survey**; forthcoming - Service, Information and Transportation Survey replaces several of the above separate surveys.**
Other Programs: County Business Patterns; Quarterly Financial Report; Annual Capital Expenditure Survey; Manufacturing and Trade Inventory and Sales; Research and Development Survey

e-Business Measurement **http://www.census.gov/econ/www/ebusiness614.htm/**
e-Stats . . . . **http://www.census.gov/estats/**
North American Industry Classification System . . . . **http://www.census.gov/naics/**
State and County Business Patterns (by NAICS) . . **http://teir2.census.gov/cbp_naics/index.html**
State and County Economic Profiles . . . . **http://www.census.gov/datamap/**

Texas State Data Center . . . . **http://txsdc.tamu.edu/**

Texas A&M University's Department of Rural Sociology is designated as the official repository of data from the Census Bureau. Materials available on a cost-reimbursable basis. Dr. Steve Murdock, Director. Inquiries:

via e-mail . . . . texassdc@txsdcsun.tamu.edu

via phone . . . . (979) 854-5115

Economics and Statistics Administration . . . . **http://www.esa.doc.gov/**

Economic Development Administration . . . . **http://www.doc.gov/eda/**

Economic Development Information Clearinghouse

"Tools of the Trade" . . . . **http://www.doc.gov/eda/html/2b_toolsoftrade.htm/**

International Trade Administration . . . . http://www.ita.doc.gov/

use site map to find policy, statistics and development assistance - all organized by industry sector

Minority Business Development Administration . . . . **http://www.mbda.gov/**

National Institute of Standards and Technology . . . . **http://www.nist.gov/**

Advanced Technology Programs . . . . **http://www.atp.nist.gov/**

Very useful search engine to produce as hoc reports on projects funded by ATP-NIST

Center for Applied Information Technology . . . . **http://waltz.ncsi.nist.gov/CAIT/cait.html/**

Chemical Science and Technology Laboratory . . . . **http://www.cstl.nist.gov/**

Electronics and Electrical Engineering Laboratory . . . . **http://www.eeel.nist.gov/**

Manufacturing Engineering Laboratory . . . . **http://www.mel.nist.gov/**

Testbed facilities and research into Internet Commerce for Manufacturing

Manufacturing Partnership Extension . . . . **http://www.mep.nist.gov/**

Materials Science and Engineering Laboratory . . . . **http://www.msel.nist.gov/**

Physics Laboratory . . . . **http://www.physics.nist.gov/**

Technology Services . . . . **http//www.ts.nist.gov/**

National Telecommunications and Information Administration . . . . **http://www.ntia.doc.gov/**

Domain Name Management . . . . http://www.nita.doc.gov/nita.home/domainname/domainhome.htm/

"Falling Through the Net" Series . . . . **http://ntia.doc.gov/**

Understanding the Digital Economy Conference Papers . . . . . . **http://www.digitaleconomy.gov/**

Technology Opportunities Program (TOP) . . **http://www.ntia.doc.gov/otiahome/top/index.html**

Formerly Telecommunications and Information Infrastructure Assistance Program (TIIAP)

Office of Small and Disadvantaged Business Utilization . . . . **http://www.doc.gov/osdbu/**

Secretariat for Electronic Commerce (E-Commerce Working Group) . . **http://www.ecommerce.gov/**

Technology Administration **http://www.go4it.gov**

Office of Technology Policy . . . . **http://ta.doc.gov/otpolicy/default.htm/**

U.S. Patent and Trademark Office . . . . **http://www.uspto.gov/**

Patents by item or geography . . . . **http://www.uspto.gov/web/offices/ac/ido/oeip/taf/reports.htm/**

U.S. Department of Education . . . . http://www.ed.gov/

Office of Educational Research and Improvement . . . . http://www.edu.gov/offices/oeri/

includes National Assessment of Educational Progress . . . . . . http://www.ed.gov/nationsreportcard/

includes **National Assessment of Academic Progress**

Mathematics (with state level data) . . . . **http://nces.ed.gov/nationsreportcard/math/**

Science (with state level data) . . . . **http://nces.ed.gov/nationsreportcard/science**

includes **National Center for Education Statistics (NCES) . . . . http://nces.ed.gov/**
NCES publications . . . . http://www.edu.gov/offices/oeri/edpubs.html/
Under NCES, see especially *Assessment of Student Achievement in Undergraduate Education* (ASA)*, Student Learning in Science, Mathematics, Engineering and Technology* (SMET), and *Reasearch on SMET Learning in Educational Settings* from the NCES's Division of Research, Evaluation and Communication.
Office of Elementary and Secondary Education . . . . http://www.edu.gov/offices/oese/
Office of Postsecondary Education . . . . http://www.edu.gov/offices/ope/
Office of Vocational and Adult Education . . . . http://www.edu.gov/offices/ovae/

U.S. Department of Energy's Office of Science and Technology . . . . http://www.ost.em.doe.gov/
see also Worldwide Performance and Innovation (below)

U.S. Department of Housing and Urban Development (jointly with US Department of Agriculture)
Empowerment and Enterprise Zones . . . . http://www.ezec.gov/

U.S. Department of Interior . . . . http://www.doi.gov/
U.S. Geological Survey . . . . http://www.usgs.gov/
especially regarding water and petroleum supply and researcy

U.S. Department of Justice . . . . http://www.usdoj.gov/
Topical index includes cybercrime, consumer protection, economic espionage, electronic fraud, hacking, infrastructure protection, and intellectual property rights protection

U.S. Department of Labor
Bureau of Labor Statistics . . . . http://www.dolbls.gov/
Foreign Worker Certification . . . . http://workforcesecurity.doleta.gov/
Employment and Training Administration . . . . http://www.doleta.gov/
Employment Laws for Small Business (elaws) . . . . http://www.dol.gov/elaws/
Employment Standards Administration
Wage and hour Division
Alien Labor Certification (H1-B Visas)
. . . . . http://www.dol.gov/esa/public/programs/whd/h1b.htm/
Occupational Health and Safety Administration . . . . http://www.osha.gov/
Office of Inspector General . . . . http://www.oig.dol.gov/
Women's Bureau . . . . http://www.dol.gov/wb/

U.S. Department of Treasury . . . . http://www.ustreas.gov/
Customs (technology imports) . . . . http://www.customs.treasury.gov/impoexpo/impoexpo.htm
Financial Crimes/Intellectual Property . . . . http://www.ustreas.gov/fincen/infinc.html/
Government Information Technology Service . . . . http://www.gits.gov/
See especially federal manpower needs assessment in the wake of pending retirement bulge among Baby Boomers in federal employment.

U.S. Government Accounting Office . . . . http://www.gao.gov/

U.S. Office of Management and the Budget (OMB) . . . . http://www.whitehouse.gov/omb/
tracks all federal grants and oversee data standards pursuant to Government Performance and Results Act (GPRA)

University of California at Berkeley, Center for Research on Telecommunication Policy
(in collaboration with Harvard, U. Michigan and others) . . . . . http://haas.berkeley.edu/~imio/crtp/

University of California at Irvine, Center for Research on Information Technology and

Organizations (CRITO) . . . . http://crito.uci.edu/

University of Houston - Clear Lake
Institute for Futures Research . . . . http://www.cl.uh.edu/futureweb/ifr.html/

University of Pennsylvania/Wharton School of Business . . . . http://www.wharton.upenn.edu/
Wharton Center for Human Resources . . . . http://www-management.wharton.upenn.edu/chr/
Wharton Emerging Technology Management Research Project
. . . . . http://emertech.wharton.upenn.edu/emertech/

University of Texas -
McCombs School of Business . . . . http://www.bus.utexas.edu/
Business, Technology and Law . . . . http://btl.bus.utexas.edu/
Center for Research in Electronic Commerce
. . . . . http://www.bus.utexas.edu/fac-res/centers/crec.asp/
***Internet Indicators* (monthly) . . . . http://www.internetindicators.com/**
Texas Business Review . . . . http://utexas.edu/depts.bbr/tbr/tempindex.html/
Telecommunications and Information Policy Institute . . . . http://www.utexas.edu/research/tipi/

Virginia Polytechnical Institution — see Worldwide Performance and Innovation below.

Verisign (digital authentication) . . . . http://www.verisign.com/

Wall Street Journal (business startup advisor) . . . . http://startupjournal.com/

Wall Street Research Network . . . . http://www.wsrn.com/
Internet Stock Index (ISDEX) . . . . http://www.wsrn.com/apps/ISDEX/

White House's National Coordination Office for High Performance Computing and Communications
. . . . http://www.hpcc.gov/

Wired Digital . . . . http://www.wired.com/news/

World Future Society (Futures Research Quarterly) . . . . http://www.wfs.org/

Worldwide Performance and Innovation (non profit at Virginia Polytechnical Institute) . . . . . http://www.wpi.org/
provides web-hosting services for the US Department of Energy and Environmental
Protection Agency with a search engine called Initiatives On-Line . . . . http://www.wpi.org/initiatives/

Xerox Corporation's Palo Alto Research Center . . . . http://www.parc.xerox.com/

Yankee Group . . . . http://yankee.group.com/

Zona Research . . . . http://www.zonaresearch.com/

InterNet Domain Name Registration and Management
(gTLD = Global Top Level Domain)

Afilias (registry for .ino gTLDs) . . . . http://www.afilias.com/

Global Name Registry (registry for .name gTLDs) . . . . http://www.theglobalname.org/

Internet Corporation for Assigned Names and Numbers (ICANN) . . . . http://www.icann.org/

InterNIC . . . . http://www.internic.net/
Look-up . . . . http://www.internic.net/whois.html/
Registry . . . . http://www.internic.net/regist.html/

ISP World's *Boardwatch* . . . . http://www.isp.com/bw/dec_domain.sector.htm/
Tracks developments in the creation of new top level domain names and the marketing ("*land rush,*" "cyber*squatting,*" "*virtual real estate*," "*domain-name profiteering,*" and resale) of domain names of companies like BuyDomains.com, Afternic.com, Greatdomains.com and Wodex.com

Museum Domain Management Association (registry for .museum gTLDs) . . . . http://www.musedoma.org/

National Cooperative Business Association (registry for .coop gTLDs) . . . . http://www.cooperative.org/

Network Solutions (registry for .org, .com and .net gTLDs) . . . . http://www.networksolutions.com/
Register, look-up availability of unused domain names, start-up advice

Neulevel (registry for .biz gTLDs) . . . . http://www.neulevel.com

RegistryPro (registry for .pro gTLDs) . . . . http://www.registrypro.com/
will provided restricted space for certified professionals qualifying to use second level domains of .doc, .law, .cpa, .eng, and .arc (e.g., www.arthuranderson.cpa.pro)

Societe Internationale de Telecommunications Aeronautiques (Registry for .aero gTLDs) . . . . http://www.sita.int/

Useful InterNet Navigation Tools

America's Career InfoNet . . . . http://www.acinet.org/acinet/

America's Job Bank and America's Talent Bank . . . . http://www.ajb.dri.us/

America's Learning Exchange . . . . http://www.alx.org/

Digital Divide Network . . . . http://www.digitaldividenetwork.org/content/search.index.cfm/

Economagic (US economic time series data) . . . . http://www.economagic.com

Education Resource Specific . . . . http://www.school.net/

Governor's Job Bank (Texas) . . . . http://www.twc.state.tx.us/jobs/gvjb/gvjb.html/

Multi-Ethnic E-Commerce . . . . http://www.OneNetNow.com/

National Science Board . . . . http://nsf.gov/cgi-bin/pubsys/browser/
browser to locate math, science and engineering-related reports and data from government sources

Pew Internet and American Life
Data Dump (Internet measures) . . . . http://www.pewinternet.org/datadump/index.asp/
Research Engine . . . . http://www.perinternet.org/engine/index.asp/

State Higher Education Executive Officers (SHEEO) . . . . http://www.sheeo.org/

State Science and Technology Institute . . . . http://ssti.org/

Texas Government (state, regional, county, local web-resource guide)
. . . . http://www.piperinfo.com/state/state_detail.cfm?state=Texas/

United States (federal government portal) . . . . http://www.firstgov.gov/

Technology Transfer and Intellectual Properties

In Texas

Baylor College of Medicine Office of Technology Administration
. . . . http://research.bcm.tcm.edu/OTA/index.htm/

Microelectronics and Computer Corporation (strategic research)
. . . . http://www.mcc.com/projects/st/

Rand Corporation (listing of federal R&D in Texas) . . . http://www.rand.org/MR/MR1194/MR1194.chapter45.pdf

Rice University Office of Technology Transfer . . . . http://ott.rice.edu/

Sematech . . . . http://www.sematech.org/

Southern Methodist University Research Administration and Technology Management
. . . . http://www.smu.edu/~SMU_Res/techtran.htm/

Texas A&M University System Technology Licensing Office
. . . . http://tlo.tamu.edu/ or http://engineer.tamu.edu/tlo/

Texas Centers for Border Economic Development . . . . http://www.borderbase.utep.edu/

Texas Engineering Extension Service . . . . http://teexweb.tamu.edu/index.html/

Texas State Transportation Technology Transfer Center
Local Technical Assistance Program contact . . . . http://teexcit.tamu.edu/texasltap/

Texas Tech University Office of Research Services . . . . http://www.osr.ttu.edu/

TRW Innovations Technology Bank . . . . http://www.trw.com/innovations/

University of Houston Intellectual Property Management
. . . . http://www.research.uh.edu/otm/techmanage.html/

University of Texas at Austin

Office of Technology Licensing and Intellectual Properties
. . . . http://www.utexas.edu/academic/otl/alltechs.html

IC2 Institute http://www.utexas.edu/depts/ic2/

University of Texas at Dallas . . . . http://www.utdallas.edu/administration/

University of Texas Health Science Center at Houston
. . . . http://www.uth.edu/otm/techavailable.html/

University of Texas M.D. Anderson Cancer Center
. . . . http://www.mdanderson.org/~otd/shop0199.pdf/

University of Texas Medical Branch . . . . http://www.utmb.edu/rds/tmocat.htm/

University of Texas Southwestern Medical Center at Dallas
. . . . http://www2.swmed.edu/technology_development/

University of Texas System General Counsel on Intellectual Properties
. . . . http://gold.utsystem.edu/OGC/IntellectualProperty/Index.html/

W3C Technical Reports and Publications http://www.w3.org/tr/

Elsewhere

Argonne National Lab (Industrial Technology Development) . . . . http://www.anl.gov/

Association of University Technology Managers . . . . http://www.autm.net/

BTG International (European intellectual properties brokering) . . . . http://www.btgplc.com/technologies/

Copyright Resources on the Internet http://groton.k12.ct.us/mts/pt2a.htm/

Electronic Frontier Foundation . . . . http://www.eff.org/pub/intellectual_property/

Intellectual Property Online: Patent, Trademark, Copyright Archive.

Federal Communications Commission . . . . http://www.fcc/gov

3rd Generation Wireless http://www.fcc.gov/3g/

Broadband . . . . http://www.fcc.gov/broadband/

Office of Engineering and Technology . . . . http://www.fcc.gov/oet

Federal Laboratory Consortium for Technology Transfer . . . . http://www.fedlabs.org/start.html/

Food and Drug Administration

Center for Biologics Evaluation and Research

Manufacturers Assistance . . . . http://www.fda.gov/cber/manufacturer.htm/

Center for Devices and Radiologic Health

Division of Small Manufacturing Assistance . . . . http://www.fda.gov/cdrh/dsma/

Gulf Coast Alliance for Technology Transfer at the University of Florida
. . . . http://www.gerc.eng.ufl.edu/gcatt.htm/

HelloBrain (commercial intellectual properties brokering) . . . . http://www.hellobrain.com/

IPEX.com (commercial intellectual properties brokering) . . . . http://ipex.com/

National Aeronautic and Space Administration (NASA)
Johnson Space Center . . . . http://technology.jsc.nasa.gov/home.htm/
Office of Chief Technologist . . . . http://www.hq.nasa.gov/office/codea/codeaf
Science and Technology Information . . . . http://www.sti.nasa.gov/

National Association of Management and Technical Assistance Centers . . . . http://www.namtac.org/
Texas affiliates: Northwest Texas Small Business Development Center at Texas Tech University; Center for Economic Development at the University of Texas - San Antonio; El Paso Community College; Southwest Trade Adjustment Assistance Center at the University of Texas - San Antonio; Center for Energy and Economic Diversification at the University of Texas - Permian Basin; Center for Economic Development Research and Services at the University of Texas - Arlington; Small Business Development Center at the University of Houston.

National Business Incubation Association
. . . . http://ra.cs.ohiou.edu/gopher/dept.servers/aern/homepage/nbia.html/

National Institute of Health (NIH) Office of Technology Transfer . . . . http://ott.od.nih.gov/

National Technology Transfer Center . . . . http://www.nttc.edu/flash/html_version/

Rand Corporation
Bibliography of R&D efforts and experiences http://www.rand.org/publications/bib/SB2029.pdf
Federal R&D state-by-state http://www.rand.org/publications/MR/MR1194/

Richard C. Byrd Institute . . . . http://www.rcbi.org/

Small Business Administration
Small Business Technology Transfer Program . . . . http://www.sba.gov/SBIR/sttr.html/
Cooperative arrangements with small businesses under STTR are negotiated separately through the Department of Defense, National Institutes of Health’s Office of Extramural Research, National Aeronautics and Space Administration (NASA); Department of Energy; National Science Foundation; Department of Agriculture; Department of Education; Environmental Protection Agency’s National Center for Environmental Research *Science to Achieve Results* program; the Department of Transportation; and the Department of Health and Human Services.

U.S. Department of Agriculture
Technology Transfer Information Center . . . . http://www.nal.usda.gov/ttic/
See also Biotechnology Information Center, Plant Genome Data and Information Center, and the Economic Research Service

US Department of Commerce

Minority Business Development Agency . . . . http://www.mbda.gov/

Technology Administration

National Institute of Standards and Technology . . . . http://www.nist.gov/

(Includes NIST's Measurement and Standards Laboratories; Electronics and Electrical Engineering Laboratory; Information Technology Laboratory; Manufacturing Engineering Laboratory (including atomic and molecular measurement research for electronics manufacturing); Automated Production Technology work group; Manufacturing Systems Integration work group; National Advanced Manufacturing Testbed; Advanced Technologies Program; Materials Science and Research (includes work groups on ceramics, polymers, metallurgy, neutron research, and the Building and Fire Research group); Motor Vehicle Manufacturing Technology group; Chemical Science and Technology Laboratory; and the Physics Laboratory.)

See especially NIST's Manufacturing Extension Partnership . . . . http://www.mep.nist.gov/

U.S. Department of Defense

Central Contractor Registry for DoD http://www.ccr2000.com/

Defense Advance Research Projects Agency . . . . http://www.darpa.mil/

Includes information on the DoD's assistance for Small Business Innovation Research (SBIR) Small Business Technology Transfer (STTR), Small and Disadvantaged Business Utilization (SADBU), Historically Black Colleges and Universities and Minority Institution set-asides.

Defense Technical Information Center . . . . http://www.dtic.mil

See also Department of Defense Basic Research; Defense Research and Engineering; Sensors and Electronics Technology; Information Technology; High Performance Computing Modernization Office; Biological Systems; Telemedicine; Strategic Environment Research and Development; Dual Use Science and Technology; Industrial Research and Development; Advanced Materials; Chemical Propulsion; and Infrared Research divisions.

Manufacturing Technology Assistance . . . . http://dodmantech.com/pubs/

U.S. Department of Energy . . . . http:/www.energy.gov/

Office of Industrial Technologies . . . . http://www.oit.doe.gov/inventions/

See also Office of Energy Research

High Energy and Nuclear Physics; Basic Energy Science; Biological and Environmental Research; Fusion Energy Program

See also Office of Computational and Technology Research

Advanced Energy Products and Technology Research; Office of Science and Technology Information; and Mathematics, Information and Computational Division

See also Energy Efficiency and Renewable Energy - Alternative Fuels Data Center

See also Energy Technology Data Center; Energy Information Administration

US Department of the Interior

US Geological Survey Technology Transfer Partnerships

. . . . http://internet.er.usgs.gov/bio/USGS/tech-transfer/index.html/

U.S. Department of Labor

Occupational Health and Safety Administration

Division of Technical Assistance . . . . http://osha.gov/dts/index.html/

Ergonomics assistance for small business

. . . . http://www.osha-slc.gov/sltc/ergonomics/ergosmallbusiness/index.html/

U.S. Patent and Trademark Office . . . . http://www.uspto.gov/

Yet2.com (commercial intellectual properties brokering) http://www.yet2.com/

APPENDIX II

EMPLOYMENT AND EARNINGS IN TEXAS IN OCCUPATIONS RANKED BY TECHNOLOGY-INTENSITY USING THE METRIC DEVISED BY CAREER DEVELOPMENT RESOURCES

Key to the ranking metric used by the CDR and displayed in column one of the table in this appendix.

1 = Job duties are driven by advanced technology

2 = Job duties require significant use of advanced technology

3 = Job duties rely on moderate use of advanced technology

4 = Job duties require occasional use of advanced technology

5 = Job duties do not rely on the use of advanced technology

The CDR's methodology for applying this metric is explained in detail on pages 63 -67 of this report.

All data on the following pages of this index represent Texas averages for 1998 (the latest period available at the time of publication).

RANK	OES Code	OES Title	1998 Employment	Median Hourly Wage	Mean Hourly Wage	Mean Annual Earnings
1	22102	Aeronautical/Astronautical Engineers	4,210	$30.52	$29.32	$60,980
1	22105	Metallurgists/Metallurgical Engineers	740	$24.20	$25.52	$53,090
1	22117	Nuclear Engineers	440	$34.28	$31.77	$66,080
1	22126	Electrical and Electronic Engineers	28,220	$31.10	$29.55	$61,460
1	22127	Computer Engineers	23,070	$28.98	$27.99	$58,210
1	22135	Mechanical Engineers	17,270	$30.85	$28.67	$59,630
1	22138	Marine Engineers	230	$22.70	$23.96	$49,830
1	22505	Electrical and Electronic Engineers	23,230	$16.66	$17.36	$36,100
1	22514	Drafters	27,820	$16.77	$18.24	$37,940
1	22599	All Other Engineering Technicians	24,740	$15.06	$16.78	$34,890
1	25105	Computer Programmers (mainframe)	38,520	$24.32	$25.50	$53,030
1	25199	All Other Computer Scientists	4,910	$20.92	$22.47	$46,730
2	13017	Engineering/Mathematics Managers	22,750	$36.70	$35.05	$72,900
2	15021	Mining/Oil and Gas Managers	2,150	$38.47	$36.21	$75,320
2	22108	Mining Engineers	210	$26.70	$27.66	$57,520
2	22111	Petroleum Engineers	5,280	$37.54	$35.23	$73,280
2	22114	Chemical Engineers	5,550	$33.73	$31.13	$64,750
2	22121	Civil Engineers, Including Traffic	11,270	$28.09	$27.51	$57,230
2	22128	Industrial Engineers, Except Safety	7,350	$28.73	$27.59	$57,380
2	22132	Safety Engineers, Except Mining	3,180	$25.38	$27.19	$56,560
2	22199	All Other Engineers	32,070	$30.19	$29.75	$61,880

RANK	OES Code	OES Title	1998 Employment	Median Hourly Wage	Mean Hourly Wage	Mean Annual Earnings
2	22302	Architects, Except Landscape	4,460	$20.95	$23.20	$48,250
2	22305	Marine Architects	40	$29.29	$27.75	$57,720
2	22311	Surveyors and Mapping Scientists	2,670	$15.44	$18.44	$38,360
2	22502	Civil Engineering Technicians	5,000	$14.16	$15.85	$32,970
2	22511	Mechanical Engineering Technicians	6,170	$19.76	$20.64	$42,930
2	22517	Estimators and Drafters, Utility	460	$18.68	$19.80	$41,190
2	24102	Physicists and Astronomers	110	$35.93	$34.20	$71,140
2	24105	Chemists, Except Biochemists	4,780	$22.40	$24.04	$50,010
2	24111	Geologists/Geophysicists	5,530	$39.20	$36.14	$75,160
2	24199	All Other Physical Scientists	4,460	$20.87	$23.80	$49,510
2	24302	Foresters and Conservation Scientists	680	$21.03	$21.66	$45,060
2	24305	Agricultural and Food Scientists	650	$18.78	$19.84	$41,260
2	24308	Biological Scientist	3,360	$20.92	$23.26	$48,370
2	24311	Medical Scientists	1,290	$30.30	$31.04	$64,570
2	24399	All Other Life Scientists	2,580	$26.22	$27.53	$57,260
2	24502	Biological/Agricultural Scientists	1,910	$11.10	$12.09	$25,160
2	25102	Systems Analysts, Electronic Data	40,920	$23.54	$24.86	$51,710
2	25103	Data Base Administrators	7,270	$22.88	$23.70	$49,310
2	25104	Computer Support Specialists	35,460	$17.99	$19.63	$40,840
2	25108	Computer Programmer Aides	3,740	$14.04	$14.87	$30,920
2	25111	Programmers, Numerical Tool	510	$18.96	$19.55	$40,670
2	27105	Urban and Regional Planners	1,360	$19.20	$19.96	$41,510
2	31508	Audio-Visual Specialists	1,380	$17.33	$17.23	$35,850
2	34028	Broadcast Technicians	2,430	$8.89	$11.18	$23,260
2	85505	Frame Wirers, Central Office	2,490	$21.63	$20.92	$43,510
2	85599	Communications Equip Repair, NEC	3,760	$18.02	$17.57	$36,550
2	85702	Telephone/Cable TV Repair/Installers	16,290	$13.89	$15.29	$31,810
2	85705	Data Processing Equipment Repairer	6,100	$11.27	$12.86	$26,740
2	85717	Electronics Repairers, Commercial	6,000	$15.69	$16.27	$33,840
2	85721	Powerhouse, Substation Electricians	540	$21.68	$21.08	$43,850
2	85799	Electrical/Electronic Repairers, NEC	7,480	$16.39	$14.91	$31,010
3	13005	Personnel/Training Managers	16,510	$23.67	$24.92	$51,830
3	13011	Marketing/Advertising Managers	32,480	$28.49	$29.20	$60,730
3	21114	Accountants and Auditors	70,670	$18.16	$19.73	$41,030
3	21117	Budget Analysts	3,770	$20.03	$21.94	$45,640
3	21199	All Other Financial Specialist	16,890	$18.42	$21.05	$43,790
3	21511	Personnel/Training/Labor Specialists	23,850	$18.37	$20.12	$41,850
3	21905	Management Analysts	7,700	$23.45	$25.73	$53,510
3	21908	Construction and Building Inspectors	3,110	$17.06	$18.08	$37,600
3	22308	Landscape Architects	790	$18.88	$20.73	$43,110
3	24108	Atmospheric and Space Scientists	530	$19.41	$21.42	$44,560
3	24511	Petroleum Technicians/Technologists	3,490	$20.12	$20.86	$43,390
3	25302	Operations and Systems Researchers	5,710	$25.30	$25.85	$53,770
3	31114	Nursing Instructors, Postsecondary	2,280	$0.00	$0.00	$41,790
3	31314	Teachers and Instructors, Vocational	22,180	$15.95	$16.99	$35,340
3	31511	Curators, Archivists, Museum Techs	540	$12.73	$14.66	$30,480
3	32102	Physicians and Surgeons	28,000	$0.00	$52.04	$108,250
3	32105	Dentists	5,560	$51.45	$43.52	$90,520
3	32114	Veterinarians/ Veterinary Inspectors	2,000	$24.70	$27.26	$56,710
3	32302	Respiratory Therapists	6,120	$15.33	$15.41	$32,050
3	32308	Physical Therapists	7,740	$29.83	$29.07	$60,460
3	32314	Speech-Language Path/Audiologists	6,450	$18.51	$19.78	$41,150
3	32399	All Other Therapists	5,040	$8.88	$10.80	$22,460
3	32502	Registered Nurses	125,070	$18.93	$19.88	$41,360
3	32508	Emergency Medical Technicians	7,810	$8.83	$9.77	$20,320
3	32511	Physician Assistants	4,750	$16.56	$20.13	$41,870
3	32902	Medical and Clinical Lab Technologists	10,410	$16.05	$16.75	$34,830
3	32905	Medical and Clinical Lab Technicians	9,370	$11.59	$12.22	$25,420
3	32908	Dental Hygienists	7,360	$21.47	$22.20	$46,170
3	32913	Radiation Therapists	810	$17.56	$17.75	$36,920
3	32914	Nuclear Medicine Technologists	830	$18.13	$18.40	$38,260
3	32919	Radiologic Technologists	8,850	$14.12	$14.61	$30,390

RANK	OES Code	OES Title	1998 Employment	Median Hourly Wage	Mean Hourly Wage	Mean Annual Earnings
3	32923	Electroneurodiagnostic Technologists	270	$15.15	$15.50	$32,240
3	32925	Cardiology Technologists	1,250	$17.07	$17.37	$36,120
3	32926	Electrocardiograph Technicians	690	$10.48	$11.42	$23,750
3	32928	Surgical Technologists/Technicians	3,890	$11.01	$11.28	$23,450
3	34005	Technical Writers and Editors	3,370	$18.95	$19.40	$40,350
3	34008	Public Relations Specialists	4,890	$16.81	$18.74	$38,970
3	34023	Photographers	3,800	$9.70	$11.39	$23,690
3	34032	Film Editors	570	$16.74	$16.57	$34,450
3	39005	Traffic Technicians	300	$13.38	$14.54	$30,250
3	39999	Prof./Paraprofessional Wkrs., NEC	56,710	$18.04	$20.24	$42,090
3	43023	Sales Agents, Advertising	8,880	$14.86	$18.28	$38,020
3	49005	Sales Representatives, Scientific	30,680	$21.80	$24.89	$51,760
3	66002	Dental Assistants	15,340	$9.93	$10.81	$22,490
3	79806	Veterinary Assistants	3,710	$7.39	$7.58	$15,770
3	81002	First-Line Supervisors, Mechanics	33,310	$18.56	$19.98	$41,550
3	81011	First-Line Supervisors, Transportation	11,350	$16.57	$17.14	$35,660
3	83002	Precision Inspectors/Testers/Graders	10,850	$13.27	$14.19	$29,510
3	85302	Automotive Mechanics	42,810	$12.81	$13.53	$28,140
3	85308	Motorcycle Repairers	630	$11.28	$12.02	$25,000
3	85311	Bus and Truck Mechanics, Diesel	17,740	$13.15	$13.40	$27,870
3	85314	Mobile Heavy Equipment Mechanic	7,710	$12.87	$13.55	$28,180
3	85323	Aircraft Mechanics	12,220	$17.03	$17.69	$36,790
3	85326	Aircraft Engine Specialists	2,300	$19.25	$18.81	$39,120
3	85328	Small Engine Specialists	1,950	$8.29	$9.36	$19,470
3	85502	Central Office and PBX Installers	2,320	$20.23	$18.94	$39,380
3	85514	Radio Mechanics	430	$19.14	$17.80	$37,020
3	85708	Home Electronic Entertain Repairer	2,730	$11.12	$11.81	$24,570
3	85711	Electric Home Appliance Repairers	2,870	$10.80	$11.44	$23,800
3	85714	Electric Motor, Transformer Repairers	1,850	$10.42	$10.98	$22,830
3	85723	Electrical Power-Line Installers	6,490	$16.43	$16.01	$33,310
3	85726	Station Installers and Repairers	1,170	$17.72	$16.98	$35,320
3	85728	Electrical Installers and Repairers	1,350	$14.79	$14.56	$30,290
3	85905	Precision Instrument Repairers	3,880	$20.44	$19.11	$39,740
3	85908	Electro- and Biomedical Repairers	1,380	$12.64	$13.05	$27,140
3	85932	Elevator Installers and Repairers	1,080	$16.91	$16.95	$35,250
3	87202	Electricians	43,530	$14.79	$14.94	$31,080
3	89108	Machinists	30,110	$12.78	$13.39	$27,860
3	89706	Paste-Up Workers	250	$7.94	$8.51	$17,700
3	89707	Electronic Pagination Operators	1,840	$12.16	$12.64	$26,280
3	89712	Photoengravers	210	$9.81	$11.62	$24,170
3	89713	Camera Operators	390	$9.89	$11.11	$23,110
3	89715	Scanner Operators	280	$16.79	$16.56	$34,450
3	89719	Lithography/Photography Wkrs., NEC	180	$17.73	$18.61	$38,700
3	89799	All Other Precision Printing Workers	320	$13.83	$13.34	$27,740
3	89914	Precision Photographic Process Wkrs.	460	$9.26	$10.43	$21,690
3	89923	Medical Appliance Makers	240	$10.72	$12.05	$25,060
3	91102	Sawing Machine Tool Setters	1,410	$9.57	$9.89	$20,580
3	91105	Lathe/Turning Machine Tool Setters	3,120	$11.58	$12.10	$25,170
3	91108	Drilling/Boring Machine Tool Setters	1,490	$10.26	$10.75	$22,360
3	91111	Milling and Planing Machine Setters	740	$13.71	$13.60	$28,290
3	91114	Grinding, Lapping, and Buffing Setters	3,330	$10.00	$10.88	$22,630
3	91302	Punching Machine Setters	2,010	$9.99	$10.10	$21,000
3	91305	Press/ Press-Brake Machine Setters	3,320	$11.27	$11.67	$24,280
3	91308	Shear and Slitter Machine Setters	1,080	$9.85	$10.24	$21,300
3	91311	Extruding/Drawing Machine Setters	2,480	$10.35	$10.92	$22,710
3	91314	Rolling Machine Setters	660	$9.66	$10.20	$21,220
3	91317	Forging Machine Setters	610	$11.94	$12.16	$25,280
3	91502	Numerical Control Machine Tool Oper.	3,950	$13.17	$13.19	$27,430
3	91505	Combination Machine Tool Setter	1,960	$11.08	$11.18	$23,250
3	91702	Welding Machine Setters	1,770	$10.96	$11.42	$23,750
3	91708	Soldering and Brazing Machine Setters	220	$10.84	$10.54	$21,930
3	91714	Metal Fabricators, Structural	3,140	$8.43	$9.55	$19,860

RANK	OES Code	OES Title	1998 Employment	Median Hourly Wage	Mean Hourly Wage	Mean Annual Earnings
3	91902	Plastic Molding Machine Setters	1,780	$9.25	$10.17	$21,150
3	91908	Metal Molding, Coremaking Setters	720	$9.48	$9.78	$20,350
3	91917	Electrolytic Plating Machine Setters	800	$10.33	$10.92	$22,720
3	91923	Nonelectrolytic Plating Machine Setters	350	$8.93	$9.80	$20,390
3	91928	Heating Equipment Setters, Metal	140	$12.15	$12.59	$26,180
3	92302	Sawing Machine Setters	230	$9.12	$9.67	$20,120
3	92311	Woodworking Machine Setters	1,120	$7.97	$8.60	$17,890
3	92510	Printing Press Machine Setters	540	$11.87	$12.02	$25,000
3	92512	Offset Lithographic Press Setters	4,020	$11.59	$12.41	$25,800
3	92515	Letterpress Setters	470	$11.20	$14.12	$29,380
3	92519	All Other Printing Press Setters	750	$13.97	$15.91	$33,090
3	92522	Specialty Materials Printing Setter	790	$11.25	$11.25	$23,390
3	92524	Screen Printing Machine Setter	2,030	$8.38	$8.77	$18,250
3	92525	Bindery Machine Setters	1,350	$9.80	$11.07	$23,030
3	92529	Printing Related Machine Setters, NEC	350	$9.88	$10.56	$21,970
3	92545	Photoengraving/Lithographic Operators	270	$9.40	$10.29	$21,390
3	92702	Textile Machine Setters	400	$9.37	$9.42	$19,590
3	92902	Electronic Semiconductor Processors	12,990	$12.18	$13.44	$27,960
3	92905	Motion Picture Projectionists	620	$6.14	$6.92	$14,390
3	92908	Photographic Process Machine Oper.	2,800	$8.20	$8.35	$17,360
3	92914	Paper Goods Machine Setters	1,960	$11.99	$12.12	$25,210
3	92932	Dairy Processing Equipment Oper.	660	$9.71	$9.44	$19,630
3	92935	Chemical Equipment Controllers	5,650	$19.73	$19.15	$39,830
3	92941	Cutting and Slicing Machine Setters	1,570	$9.52	$10.03	$20,850
3	92951	Coat/Painting/Spraying Mach. Setter	2,340	$9.52	$10.50	$21,830
3	92968	Extrude/Forming/Pressing Mach Setter	1,570	$11.50	$12.70	$26,410
3	92997	All Other Machine Setters	5,610	$10.04	$11.78	$24,510
3	93111	Electromechanical Equip Assemblers	2,580	$10.00	$10.70	$22,250
3	93114	Precision Electronic Equip. Assemblers	11,850	$9.95	$10.37	$21,580
3	93197	All Other Precision Assemblers	4,530	$9.70	$10.97	$22,820
3	93905	Electrical and Electronic Assemblers	18,740	$8.58	$9.29	$19,320
3	95008	Chemical Plant and System Operators	5,360	$22.80	$23.10	$48,050
3	95014	Petroleum Refinery Control Operators	6,390	$22.12	$21.78	$45,310
3	95021	Power-Generating Plant Operators	1,590	$20.68	$18.89	$39,300
3	95028	Power Distributors and Dispatchers	700	$18.67	$19.59	$40,750
3	95099	All Other Plant and System Operators	11,840	$10.33	$11.38	$23,670
4	13002	Financial Managers	44,970	$25.56	$27.87	$57,970
4	13008	Purchasing Managers	10,850	$20.54	$22.50	$46,810
4	13014	Administrative Services Managers	27,500	$19.16	$21.72	$45,170
4	15002	Postmasters and Mail Superintents	1,420	$21.63	$22.43	$46,660
4	15005	Education Administrators	29,380	$27.38	$27.20	$56,580
4	15008	Medicine/Health Services Managers	12,990	$21.18	$22.07	$45,900
4	15014	Industrial Production Managers	12,390	$26.74	$27.94	$58,110
4	15017	Construction Managers	17,190	$21.26	$23.75	$49,400
4	15023	Communication/Transportation Mgrs.	12,780	$23.64	$24.98	$51,950
4	15026	Food Service and Lodging Managers	26,100	$12.87	$15.10	$31,410
4	19002	Public Administration Chief Execs	2,370	$18.28	$20.46	$42,550
4	19005	General Managers and Top Execs	288,290	$23.27	$27.35	$56,900
4	19999	All Other Managers and Administrators	72,110	$22.91	$25.31	$52,650
4	21102	Insurance Underwriters	5,850	$18.51	$19.85	$41,290
4	21105	Credit Analysts	2,460	$16.18	$16.69	$34,720
4	21505	Special Agents, Insurance	1,230	$17.28	$21.82	$45,380
4	21902	Cost Estimators	11,450	$20.49	$21.88	$45,510
4	21917	Assessors	1,240	$16.61	$16.85	$35,040
4	22508	Industrial Engineering Technicians	1,850	$18.92	$20.74	$43,140
4	24505	Chemical Technicians and Technician	6,580	$16.37	$17.30	$35,980
4	25310	Mathematical Scientists	630	$19.81	$26.22	$54,530
4	25312	Statisticians	720	$21.25	$22.30	$46,390
4	25313	Actuaries	720	$31.73	$31.61	$65,750
4	25315	Financial Analysts, Statistical	2,880	$24.51	$28.11	$58,460
4	25319	All Other Mathematical Scientists	1,020	$45.53	$40.42	$84,080
4	25323	Mathematical Technicians	80	$18.66	$20.82	$43,300

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4	27102	Economists, incl. Market Research	3,260	$22.72	$23.67	$49,220
4	28302	Law Clerks	2,410	$13.70	$13.81	$28,720
4	28308	Title Searchers	680	$11.09	$12.79	$26,610
4	28311	Title Examiners and Abstractor	1,320	$13.94	$15.92	$33,120
4	31323	Farm/Home Management Advisors	720	$12.72	$15.00	$31,200
4	32911	Medical Records Technicians	5,820	$8.70	$9.39	$19,530
4	32951	Veterinary Technicians	3,060	$8.00	$8.47	$17,610
4	32999	All Other Health Professionals	37,250	$11.63	$13.98	$29,070
4	34014	Broadcast News Analysts	460	$17.69	$20.79	$43,240
4	34035	Artists and Related Workers	7,370	$14.28	$15.64	$32,530
4	34038	Designers, Except Interior Designers	13,290	$13.26	$15.35	$31,920
4	39002	Air Traffic Controllers/Air Dispatchers	2,650	$32.95	$30.16	$62,730
4	41002	First-Line Supervisors and Managers	107,830	$13.88	$16.86	$35,070
4	43002	Sales Agents and Placers, Insurance	17,260	$15.52	$20.91	$43,500
4	43014	Sales Agents, Securities/Commodities	11,460	$19.01	$25.86	$53,790
4	51002	First-Line Supervisors and Managers	104,640	$14.31	$15.67	$32,590
4	53114	Credit Authorizers	1,460	$10.36	$11.15	$23,190
4	53128	Brokerage Clerks	2,840	$11.45	$12.40	$25,800
4	53502	Welfare Eligibility Workers	2,550	$18.47	$18.07	$37,590
4	55102	Legal Secretaries	17,380	$15.31	$14.90	$31,000
4	55105	Medical Secretaries	15,400	$10.61	$11.06	$23,010
4	55108	Secretaries, Except Legal/Medical	172,410	$10.74	$11.15	$23,190
4	55314	Personnel Clerks, Except Payroll	10,870	$11.63	$12.16	$25,290
4	55323	Order Clerks, Merchandise/Service	24,100	$9.42	$10.37	$21,580
4	55326	Procurement Clerks	4,430	$10.96	$11.35	$23,610
4	55338	Bookkeeping, Accounting Clerks	114,330	$10.66	$11.13	$23,150
4	58008	Production/Planning/Expediting Clerks	19,320	$14.27	$14.57	$30,300
4	58023	Stock Clerks - Stockroom/Warehouse	58,060	$8.41	$9.35	$19,440
4	58028	Shipping, Receiving Clerks	66,780	$9.91	$10.95	$22,770
4	58099	All Other Material Recording Clerks	10,130	$9.33	$11.00	$22,880
4	61002	Fire Fighting and Prevention Supervisor	2,910	$20.39	$20.76	$43,180
4	61005	Police and Detective Supervisors	7,530	$20.20	$20.73	$43,120
4	61099	All Other Supervisors and Managers	44,680	$10.37	$11.48	$23,880
4	66017	Physical and Corrective Therapists	5,390	$8.60	$11.04	$22,960
4	72002	First-Line Supervisors and Managers	2,560	$12.01	$12.98	$27,000
4	81005	First-Line Supervisors, Construction	33,370	$17.74	$19.19	$39,920
4	81008	First-Line Supervisors, Production	38,140	$16.56	$18.34	$38,140
4	81017	First-Line Supervisors, Laborers	11,780	$13.94	$14.93	$31,050
4	81099	All Other First-Line Supervisors	20,800	$16.75	$18.42	$38,300
4	83008	Transportation Inspectors	1,850	$15.22	$15.38	$31,980
4	83099	All Other Inspectors/Testers/Graders	5,620	$11.78	$13.06	$27,160
4	85110	Machinery Maintenance Mechanics	19,530	$14.30	$15.03	$31,250
4	85116	Machinery Maint. Mechanic-Marine	370	$11.72	$12.48	$25,950
4	85902	Heating, Air Conditioning Repairers	19,880	$12.84	$13.46	$28,000
4	85911	Electric Meter Installers	800	$14.14	$15.85	$32,960
4	85917	Watchmakers	250	$9.85	$10.64	$22,130
4	85928	Mechanical Control and Valve Repairer	2,410	$14.82	$15.25	$31,730
4	85938	Installers/Repairers, Manuf. Buildings	2,790	$9.89	$10.24	$21,290
4	85944	Gas Appliance Repairers	700	$17.71	$17.38	$36,150
4	85999	All Other Mechanics, Installers	26,650	$11.65	$13.10	$27,250
4	89917	Precision Optical Goods Worker	1,390	$8.08	$8.54	$17,760
4	91117	Machine Tool Cutting Operators	3,890	$9.59	$9.93	$20,650
4	91321	Machine Forming Operators/Tenders	7,920	$8.18	$8.90	$18,510
4	91705	Welding Machine Operators/Tenders	5,420	$11.39	$11.54	$24,000
4	9 1711	Soldering/Brazing Machine Operators	370	$9.09	$9.28	$19,310
4	91905	Plastic Molding Machine Operators	5,970	$7.69	$8.04	$16,730
4	91911	Metal Molding, Coremaking Operators	1,700	$9.15	$9.78	$20,330
4	91921	Electrolytic Plating Machine Operators	1,020	$9.00	$10.19	$21,200
4	91926	Nonelectrolytic Plating machine Oper.	310	$11.62	$12.07	$25,100
4	91932	Heat Treating/Annealing Operators	1,240	$10.56	$11.07	$23,030
4	91935	Furnace Operators and Tenders	1,090	$10.25	$10.55	$21,950
4	92308	Sawing Machine Operators/Tenders	1,710	$7.96	$8.51	$17,700

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4	92314	Woodworking Machine Operators	2,190	$7.57	$8.05	$16,750
4	92543	Printing Press Machine Operators	5,450	$11.14	$12.04	$25,050
4	92546	Bindery Machine Operators	2,990	$8.61	$9.66	$20,100
4	92549	Printing, Binding Operators, NEC	1,160	$9.91	$10.35	$21,540
4	92705	Textile Machine Operators	3,220	$7.79	$8.03	$16,710
4	92708	Extruding and Forming Machine Oper.	1,150	$14.35	$14.22	$29,580
4	92717	Sewing Machine Operators, Garment	19,930	$7.14	$7.19	$14,960
4	92721	Sewing Machine Oper., Nongarment	7,950	$7.33	$7.58	$15,760
4	92723	Shoe Sewing Machine Operators	720	$7.33 $	7.38	$15,360
4	92923	Furnace/Kiln/Oven/Drier Operators	2,020	$12.51	$13.42	$27,910
4	92928	Cooling and Freezing Equipment Oper.	470	$7.13	$7.54	$15,680
4	92944	Cutting and Slicing Machine Operators	3,540	$8.67	$9.26	$19,250
4	92956	Cementing and Gluing Machine Oper.	1,620	$8.89	$8.98	$18,670
4	92958	Cleaning, Washing Mach. Operator	1,040	$8.30	$9.40	$19,550
4	92962	Separating, Filtering Machine Operator	4,280	$16.67	$16.49	$34,300
4	92965	Crushing, Grinding, Mixing Mach. Oper.	9,100	$9.01	$9.88	$20,560
4	92971	Extrude/Forming/Pressing Mach Oper.	3,930	$9.73	$10.01	$20,830
4	92974	Packaging and Filling Machine Oper.	19,290	$8.52	$9.51	$19,780
4	92998	All Other Machine Operators	25,030	$8.70	$9.93	$20,660
4	93908	Coil Winders, Tapers, and Finishers	1,010	$8.51	$9.47	$19,690
4	95002	Water/Waste Treatment Operators	9,390	$11.37	$12.22	$25,430
4	95005	Gas Plant Operators	2,250	$19.05	$18.20	$37,860
4	95011	Petroleum Pump System Operators	1,970	$23.45	$24.38	$50,720
4	95017	Gaugers	1,910	$17.97	$17.06	$35,480
4	95023	Auxiliary Equipment Operators	430	$20.87	$20.04	$41,680
4	95026	Power Reactor Operators	330	$30.82	$28.49	$59,260
4	95032	Stationary Engineers	1,120	$16.05	$16.31	$33,930
4	97502	Captains, Water Vessel	1,090	$21.14	$21.70	$45,140
4	97508	Pilots, Ship	360	$22.65	$30.62	$63,690
4	97511	Motorboat Operators	80	$16.29	$13.62	$28,320
4	97521	Ship Engineers	660	$18.59	$19.98	$41,560
4	97702	Aircraft Pilots and Flight Engineers	9,190	$0.00	$0.00	$84,700
4	97917	Gas Pumping Station Operators	320	$17.34	$16.99	$35,330
4	97921	Gas Compressor Operators	290	$17.84	$18.01	$37,460
4	97951	Conveyor Operators and Tenders	2,420	$10.05	$10.15	$21,120
4	97953	Pump Operators	1,160	$16.19	$16.06	$33,410
5	15011	Property and Real Estate Managers	14,990	$12.34	$13.67	$28,430
5	15031	Nursery and Greenhouse Managers	90	$9.92	$13.22	$27,490
5	15032	Lawn Service Managers	1,170	$11.42	$12.52	$26,050
5	21108	Loan Officers and Counselors	15,470	$17.10	$20.13	$41,860
5	21111	Tax Preparers	4,120	$12.94	$15.03	$31,260
5	21502	Unemployment Claims Takers	140	$13.16	$13.17	$27,390
5	21508	Employment Interviewers, Private	4,850	$13.54	$16.46	$34,230
5	21914	Tax Examiners and Collectors	3,300	$20.75	$20.91	$43,490
5	21921	Claims Examiners, Property	2,770	$19.33	$20.53	$42,700
5	21999	All Other Management Support Wkrs.	69,290	$17.94	$19.93	$41,460
5	22521	Surveying and Mapping Technicians	5,360	$10.60	$12.11	$25,200
5	24599	All Other Physical and Life Scientists	10,310	$14.74	$16.24	$33,770
5	27108	Psychologists	3,940	$18.83	$20.63	$42,900
5	27199	All Other Social Scientists	4,620	$16.66	$18.03	$37,500
5	27302	Social Workers, Medical/Psychology	12,990	$13.51	$14.77	$30,720
5	27305	Social Workers, ex.Med/Psychology	22,120	$9.83	$11.11	$23,110
5	27307	Residential Counselors	7,130	$10.07	$12.11	$25,200
5	27308	Human Services Workers	10,520	$9.74	$10.16	$21,120
5	27311	Recreation Workers	10,000	$7.82	$8.75	$18,210
5	27502	Clergy	820	$15.69	$16.28	$33,860
5	27505	Directors, Religious Activities	170	$10.74	$13.88	$28,880
5	27599	All Other Religious Workers	50	$5.94	$7.32	$15,230
5	28102	Judges and Magistrates	2,470	$15.09	$22.81	$47,450
5	28105	Adjudicators and Hearings Officer	9,930	$12.62	$13.62	$28,340
5	28108	Lawyers	25,530	$39.11	$37.89	$78,810
5	28305	Paralegal Personnel	10,580	$16.30	$16.87	$35,090

RANK	OES Code	OES Title	1998 Employment	Median Hourly Wage	Mean Hourly Wage	Mean Annual Earnings
5	28399	All Other Legal Assistants	4,690	$15.02	$16.74	$34,820
5	31100	University/College, Faculty	38,850	$0.00	$0.00	$46,250
5	31111	Lecturers	1,430	$11.51	$12.77	$26,570
5	31117	Graduate Assistants, Teaching	5,460	$0.00	$0.00	$17,830
5	31303	Teachers, Preschool	20,530	$7.18	$8.74	$18,190
5	31304	Teachers, Kindergarten	15,710	$0.00	$0.00	$33,840
5	31305	Teachers, Elementary School	128,700	$0.00	$0.00	$35,470
5	31308	Teachers, Secondary School	127,710	$0.00	$0.00	$35,360
5	31311	Teachers, Special Education	25,070	$0.00	$0.00	$34,230
5	31317	Instructors, Nonvocational Education	6,570	$11.45	$13.63	$28,350
5	31321	Instructors and Coaches, Sport	17,870	$13.80	$14.55	$30,270
5	31399	All Other Teachers and Instructors	47,050	$0.00	$0.00	$32,020
5	31502	Librarians, Professional	10,090	$17.91	$17.73	$36,890
5	31505	Technical Assistants, Library	3,100	$8.85	$9.31	$19,360
5	31514	Vocational/Educational Counselors	14,450	$19.54	$19.55	$40,670
5	31517	Instructional Coordinators	7,650	$19.82	$19.76	$41,090
5	31521	Teacher Aides, Paraprofessional	64,100	$6.13	$6.72	$13,970
5	32108	Optometrists	1,220	$36.98	$34.30	$71,330
5	32111	Podiatrists	430	$24.28	$33.64	$69,970
5	32113	Chiropractors	1,200	$22.67	$29.03	$60,380
5	32199	Health Diagnosing Specialties, NEC	830	$22.53	$25.36	$52,740
5	32305	Occupational Therapists	4,610	$23.79	$26.46	$55,040
5	32311	Corrective and Manual Arts Therapists	220	$11.04	$13.51	$28,100
5	32317	Recreational Therapists	1,200	$11.30	$12.57	$26,140
5	32505	Licensed Practical Nurses	58,360	$12.48	$13.29	$27,640
5	32514	Opticians, Dispensing and Measuring	4,200	$9.55	$10.30	$21,420
5	32517	Pharmacists	10,600	$32.21	$29.04	$60,390
5	32519	Pharmacy Technicians and Aides	13,080	$7.79	$8.04	$16,720
5	32521	Dietitians and Nutritionists	2,410	$15.80	$16.71	$34,750
5	32523	Dietetic Technicians	1,310	$8.90	$10.25	$21,320
5	32931	Psychiatric Technicians	2,570	$8.11	$8.50	$17,690
5	34002	Writers and Editors	7,110	$14.87	$16.80	$34,950
5	34011	Reporters and Correspondents	2,270	$10.19	$12.90	$26,830
5	34017	Announcers, Radio and Television	3,320	$8.23	$11.19	$23,280
5	34021	Announcers, Except Radio and T.V.	120	$6.78	$8.19	$17,030
5	34026	Camera Operators, TV and Movies	940	$8.90	$10.57	$21,990
5	34041	Interior Designers	1,800	$16.06	$17.33	$36,040
5	34044	Merchandise Displayers	2,570	$9.07	$10.21	$21,240
5	34047	Music Directors, Singers, Composers	390	$0.00	$0.00	$25,460
5	34051	Musicians, Instrumental	1,790	$0.00	$0.00	$32,600
5	34053	Dancers and Choreographers	1,840	$5.69	$6.10	$12,680
5	34056	Producers, Directors, Actors,	6,140	$0.00	$0.00	$29,660
5	34058	Athletes, Coaches, Umpires	1,910	$0.00	$0.00	$30,800
5	39008	Radio Operators	370 $	10.10	$10.61	$22,060
5	39011	Funeral Directors and Morticians	1,990	$15.18	$16.48	$34,270
5	39014	Embalmers	290	$11.86	$14.13	$29,390
5	43005	Brokers, Real Estate	790	$16.64	$22.26	$46,300
5	43008	Sales Agents, Real Estate	7,480	$14.77	$20.19	$41,990
5	43011	Appraisers, Real Estate	2,220	$18.18	$21.03	$43,750
5	43017	Sales Agents, Business Services NEC	25,580	$16.18	$18.13	$37,700
5	43021	Travel Agents	7,890	$11.19	$11.67	$24,270
5	43099	All Other Sales Representatives	9,010	$12.48	$16.11	$33,510
5	49011	Salespersons, Retail	266,540	$7.39	$9.03	$18,780
5	49014	Salespersons, Parts	20,730	$10.44	$11.90	$24,750
5	49017	Counter and Rental Clerks	36,920	$6.54	$7.68	$15,980
5	49021	Stock Clerks, Sales Floor	76,390	$6.74	$7.47	$15,550
5	49023	Cashiers	224,660	$6.40	$6.91	$14,370
5	49026	Telemarketers, Door-To-Door Sales	32,310	$7.71	$8.68	$18,060
5	49999	All Other Sales and Related Workers	37,390	$10.92	$13.09	$27,230
5	53102	Tellers	35,650	$8.33	$8.42	$17,520
5	53105	New Accounts Clerks	8,960	$10.10	$10.22	$21,260
5	53108	Transit Clerks	820	$8.17	$8.56	$17,800

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5	53111	Loan Interviewers	1,980	$10.33	$11.24	$23,380
5	53117	Credit Checkers	3,530	$9.60	$10.33	$21,490
5	53121	Loan and Credit Clerks	13,340	$10.13	$10.73	$22,320
5	53123	Adjustment Clerks	45,480	$9.77	$10.14	$21,080
5	53126	Statement Clerks	1,200	$8.63	$8.70	$18,100
5	53302	Insurance Adjusters, Examiners	12,250	$19.61	$20.42	$42,480
5	53305	Insurance Appraisers, Auto Damage	1,190	$20.69	$20.41	$42,460
5	53308	Insurance Examining Clerks	610	$11.72	$11.74	$24,420
5	53311	Insurance Claims Clerks	12,530	$11.48	$11.75	$24,430
5	53314	Insurance Policy Processing Clerks	10,940	$10.78	$11.53	$23,970
5	53505	Investigators, Clerical	0 $	12.03	$12.00	$24,950
5	53508	Bill and Account Collectors	28,380	$10.86	$11.41	$23,730
5	53702	Court Clerks	3,670	$9.84	$9.80	$20,390
5	53705	Municipal Clerks	1,410	$10.14	$10.40	$21,620
5	53708	License Clerks	1,090	$10.35	$10.15	$21,110
5	53802	Travel Clerks	610	$9.41	$9.71	$20,190
5	53805	Reservation and Transportation Agents	25,830	$10.88	$12.02	$24,990
5	53808	Hotel Desk Clerks	10,640	$6.86	$6.91	$14,380
5	53902	Library Assistants incl. Bookmobile	6,890	$7.42	$7.85	$16,330
5	53905	Teacher Aides and Educational Asst.	39,970	$6.34	$6.89	$14,340
5	53908	Advertising Clerks	850	$9.13	$9.74	$20,260
5	53911	Proofreaders and Copy Markers	2,370	$8.27	$9.09	$18,910
5	53914	Real Estate Clerks	2,480	$8.45	$8.99	$18,700
5	55302	Stenographers and/or Court Reporters	4,290	$11.86	$13.32	$27,700
5	55305	Receptionists	88,860	$8.50	$8.89	$18,490
5	55307	Typists, Including Word Processing	18,270	$10.13	$10.32	$21,470
5	55317	Correspondence Clerks	1,320	$10.83	$10.90	$22,680
5	55321	File Clerks	21,150	$7.75	$8.27	$17,210
5	55328	Statistical Clerks	3,590	$10.13	$11.16	$23,220
5	55332	Interviewing Clerks, ex. Social Welfare	7,960	$8.34	$8.84	$18,380
5	55335	Customer Service Representatives	22,160	$11.90	$12.71	$26,430
5	55341	Payroll and Timekeeping Clerks	12,020	$11.12	$11.43	$23,770
5	55344	Billing, Cost, and Rate Clerks	19,630	$10.48	$10.96	$22,790
5	55347	General Office Clerks	216,130	$8.61	$9.31	$19,360
5	56002	Billing, Posting Clerks	6,590	$9.26	$9.98	$20,770
5	56005	Duplicating Machine Operators	4,620	$8.66	$8.85	$18,410
5	56008	Mail Machine Operators	3,170	$8.25	$8.94	$18,590
5	56011	Computer Operators, ex/ Peripherals	13,790	$11.33	$12.02	$24,990
5	56014	Peripheral EDP Equipment Operators	2,040	$11.56	$11.86	$24,670
5	56017	Data Entry Keyers, Except Composing	28,450	$9.07	$9.48	$19,720
5	56021	Data Keyers, Composing	1,480	$8.31	$9.21	$19,150
5	56099	All Other Office Machine Operators	4,940	$10.58	$11.03	$22,940
5	57102	Switchboard Operators	19,180	$8.09	$8.79	$18,280
5	57108	Central Office Operators	910	$8.81	$10.69	$22,230
5	57111	Telegraph and Teletype Operators	100	$10.54	$11.63	$24,190
5	57199	Communications Equip Operator, NEC	1,580	$8.17	$10.33	$21,480
5	57302	Mail Clerks, Except Mail Machine	8,070	$8.21	$8.47	$17,610
5	57305	Postal Mail Carriers	22,610	$16.60	$16.26	$33,810
5	57308	Postal Service Clerks	4,580	$16.45	$15.65	$32,540
5	57311	Messengers	6,280	$7.34	$8.07	$16,780
5	58002	Dispatchers, Police/Fire	5,310	$9.87	$10.07	$20,950
5	58005	Dispatchers, Except Police/ Fire	12,330	$11.47	$12.42	$25,840
5	58011	Transportation Agents	3,050	$14.40	$14.88	$30,960
5	58014	Meter Readers, Utilities	4,450	$9.32	$9.71	$20,190
5	58017	Weighers, Measurers, Checkers	2,620	$10.38	$11.53	$23,970
5	58021	Marking Clerks	1,380	$7.47	$8.02	$16,670
5	58026	Order Fillers, Wholesale and Retail	14,550	$8.22	$8.79	$18,280
5	59999	All Other Clerical/Admin. Workers	72,450	$10.09	$10.54	$21,920
5	61008	Housekeeping Supervisors	5,830	$8.38	$9.31	$19,370
5	63002	Fire Inspectors	320	$18.21	$18.62	$38,740
5	63008	Fire Fighters	13,440	$15.10	$15.23	$31,690
5	63011	Police Detectives	3,330	$16.29	$16.53	$34,370

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5	63014	Police Patrol Officers	28,330	$15.63	$15.87	$33,020
5	63017	Correction Officers and Jailer	43,700	$11.79	$11.54	$24,000
5	63021	Parking Enforcement Officers	240	$9.66	$9.67	$20,110
5	63023	Bailiffs	690	$10.92	$11.00	$22,880
5	63028	Criminal Investigators, Public	1,980	$28.90	$26.69	$55,510
5	63032	Sheriffs and Deputy Sheriffs	4,990	$12.75	$12.60	$26,200
5	63035	Detectives and Investigators	2,300	$9.62	$11.26	$23,410
5	63041	Fish and Game Wardens	460	$18.81	$18.58	$38,650
5	63044	Crossing Guards	2,400	$6.21	$7.12	$14,810
5	63047	Guards and Watch Guards	71,400	$7.32	$8.47	$17,610
5	63099	All Other Protective Service Workers	11,640	$12.60	$12.35	$25,690
5	65002	Hosts and Hostesses, Restaurant	16,560	$5.92	$6.19	$12,880
5	65005	Bartenders	23,360	$5.88	$6.13	$12,740
5	65008	Waiters and Waitresses	132,090	$5.80	$5.88	$12,240
5	65011	Food Servers, Outside	2,730	$6.04	$6.39	$13,300
5	65014	Dining Room and Cafeteria Attendant	26,170	$5.84	$5.94	$12,360
5	65017	Counter Attendants - Lunchroom	18,000	$6.05	$6.35	$13,210
5	65021	Bakers, Bread and Pastry	8,090	$7.46	$7.76	$16,150
5	65023	Butchers and Meat Cutters	8,850	$9.66	$10.07	$20,940
5	65026	Cooks, Restaurant	50,170	$6.91	$7.25	$15,080
5	65028	Cooks, Institution or Cafeteria	34,780	$6.84	$7.10	$14,770
5	65032	Cooks, Fast Food	36,950	$5.85	$6.02	$12,520
5	65035	Cooks, Short Order	7,390	$6.47	$6.82	$14,180
5	65038	Food Preparation Workers	74,100	$6.17	$6.66	$13,840
5	65041	Combined Food Prep/Servcie Workers	149,650	$5.88	$5.97	$12,420
5	65099	All Other Food Service Workers	23,720	$6.17	$6.87	$14,280
5	66005	Medical Assistants	19,420	$9.26	$9.43	$19,610
5	66008	Nursing Aides and Orderlies	88,230	$6.35	$6.70	$13,940
5	66011	Home Health Aides	43,000	$6.99	$8.09	$16,830
5	66014	Psychiatric Aides	4,170	$7.89	$8.20	$17,050
5	66021	Occupational Therapy Assistant	910	$16.92	$16.98	$35,330
5	66023	Ambulance Drivers and Attendants	800	$8.66	$8.90	$18,510
5	66099	All Other Health Service Workers	18,100	$7.68	$8.25	$17,150
5	67002	Maids and Housekeeping Cleaners	58,660	$5.95	$6.22	$12,930
5	67005	Janitors/Cleaners, ex. Housekeepers	130,360	$6.48	$7.00	$14,570
5	67008	Pest Controllers and Assistants	3,330	$10.95	$10.97	$22,820
5	67099	Cleaning/Building Services Wkrs., NEC	15,420	$7.48	$8.43	$17,530
5	68002	Barbers	810	$9.52	$10.57	$21,980
5	68005	Hairdressers/Stylists/Cosmetologists	22,260	$6.89	$8.46	$17,590
5	68008	Manicurists	1,440	$6.54	$8.58	$17,860
5	68011	Shampooers	790	$6.60	$6.89	$14,340
5	68014	Amusement and Recreation Attendant	15,090	$6.00	$6.72	$13,980
5	68017	Guides	900	$6.28	$8.27	$17,200
5	68021	Ushers, Lobby Attendants	5,200	$5.90	$5.92	$12,320
5	68023	Baggage Porters and Bellhops	3,140	$6.80	$7.02	$14,600
5	68026	Flight Attendants	10,710	$0.00	$0.00	$66,160
5	68028	Transportation Attendants ex. Flight	670	$7.08	$8.51	$17,700
5	68032	Wardrobe/Locker Attendants	360	$7.30	$7.87	$16,370
5	68035	Personal and Home Care Aides	28,320	$5.82	$5.94	$12,350
5	68038	Child Care Workers	27,180	$6.11	$6.44	$13,400
5	68041	Funeral Attendants	1,810	$6.35	$7.71	$16,030
5	69999	All Other Service Workers	15,670	$7.13	$8.18	$17,020
5	73002	Fallers and Buckers	330	$12.96	$12.71	$26,440
5	73008	Log-Handling Equipment Operators	510	$13.66	$13.27	$27,590
5	73011	Logging Tractor Operators	800	$11.39	$11.50	$23,920
5	79008	Log Graders and Scalers	180	$9.91	$10.65	$22,150
5	79011	Graders and Sorters, Agricultural	2,910	$6.02	$6.87	$14,290
5	79015	Animal Breeders	70	$7.98	$8.50	$17,680
5	79016	Animal Trainers	300	$10.45	$11.17	$23,220
5	79017	Animal Caretakers, Except Farm	5,830	$6.65	$7.35	$15,290
5	79021	Farm Equipment Operators	2,380	$6.57	$6.90	$14,350

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5	79036	Sprayers/Applicators	1,090	$11.02	$10.78	$22,410
5	79041	Laborers, Landscaping/Groundskeeper	58,440	$7.44	$7.80	$16,210
5	79856	Farmworkers, Food and Fiber	4,820	$5.83	$5.79	$12,030
5	79858	Farmworkers, Farm/Ranch Animals	1,080	$6.64	$7.47	$15,540
5	79999	Agricultural/Forest/Farm Wkrs., NEC	6,140	$7.07	$7.99	$16,620
5	83005	Production Inspectors/Testers/Graders	25,680	$9.51	$10.76	$22,370
5	85112	Machinery Maint. Mechanic-Textiles	240	$10.04	$9.89	$20,570
5	85113	Machinery Maint. Mechanic-Sewing	660	$9.78	$10.20	$21,220
5	85118	Machinery Maint. Mechanic-Power	6,070	$17.05	$16.88	$35,100
5	85119	Machinery Maint. Mechanics, NEC	3,810	$15.82	$15.70	$32,650
5	85123	Millwrights	4,600	$14.72	$15.10	$31,410
5	85126	Refractory Materials Repairers	150	$12.52	$13.16	$27,380
5	85128	Machinery Maintenance Workers	6,360	$14.78	$15.35	$31,930
5	85132	Maintenance Repairers, General	84,530	$9.73	$10.72	$22,300
5	85305	Automotive Body Repairers	12,210	$12.47	$13.54	$28,170
5	85317	Rail Car Repairers	900	$14.42	$15.06	$31,320
5	85321	Farm Equipment Mechanics	2,470	$9.82	$10.32	$21,460
5	85914	Camera/Photographic Equipt Repairer	360	$12.61	$13.33	$27,730
5	85921	Musical Instrument Repairers	210	$14.60	$15.87	$33,010
5	85923	Locksmiths and Safe Repairers	990	$8.22	$9.77	$20,310
5	85926	Office Machine/Cash Register Repairer	3,730	$13.04	$13.62	$28,340
5	85935	Riggers	1,050	$15.18	$14.99	$31,190
5	85947	Coin and Vending Machine Servicers	1,420	$10.24	$10.33	$21,500
5	85951	Bicycle Repairers	220	$7.54	$7.84	$16,300
5	85953	Tire Repairers and Changers	7,230	$7.75	$8.07	$16,780
5	85956	Menders, Garments, Linens	810	$6.46	$6.84	$14,230
5	87102	Carpenters	33,850	$11.58	$12.10	$25,180
5	87105	Ceiling Tile Installers	1,220	$12.39	$12.52	$26,040
5	87108	Drywall Installers	8,390	$12.31	$12.19	$25,340
5	87111	Tapers	1,100	$11.41	$10.96	$22,800
5	87114	Lathers	600	$12.60	$13.86	$28,840
5	87302	Brickmasons	5,440	$14.48	$13.76	$28,620
5	87305	Stonemasons	410	$12.59	$12.58	$26,160
5	87308	Hard Tile Setters	800	$11.88	$11.93	$24,820
5	87311	Concrete and Terrazzo Finishers	17,590	$10.04	$10.34	$21,510
5	87314	Reinforcing Metal Workers	2,740	$10.76	$10.63	$22,110
5	87317	Plasterers and Stucco Masons	1,610	$12.82	$12.97	$26,970
5	87402	Painters/Paperhangers, Construction	20,070	$10.58	$10.61	$22,060
5	87502	Plumbers, Pipefitters	27,580	$14.73	$14.90	$30,980
5	87505	Pipelaying Fitters	390	$13.58	$13.05	$27,150
5	87508	Pipelayers	3,980	$9.70	$10.34	$21,500
5	87511	Septic Tank/Sewer Servicers	170	$10.77	$10.43	$21,700
5	87602	Carpet Installers	1,650	$10.94	$10.91	$22,680
5	87605	Floor Layers, Except Carpet	210	$10.51	$10.65	$22,150
5	87608	Floor Sanding Machine Operator	200	$12.16	$12.06	$25,080
5	87702	Air Hammer Operators	70	$10.55	$12.15	$25,270
5	87708	Paving, Surfacing, and Tamping Wkrs.	8,330	$10.12	$10.41	$21,660
5	87711	Highway Maintenance Worker	8,830	$10.03	$10.26	$21,350
5	87714	Rail-Track Laying/Maintenance Wkrs.	790	$14.40	$13.46	$27,990
5	87802	Insulation Workers	6,830	$11.97	$12.33	$25,640
5	87803	Hazardous Materials Removal Workers	2,370	$10.40	$10.37	$21,560
5	87805	Sheet Metal Duct Installers	3,000	$10.69	$11.84	$24,640
5	87808	Roofers	4,980	$9.94	$10.31	$21,440
5	87811	Glaziers	3,360	$11.65	$11.58	$24,080
5	87814	Structural Metal Workers	4,690	$12.41	$12.45	$25,900
5	87817	Fence Erectors	1,760	$6.92	$7.85	$16,320
5	87899	All Other Construction Trades	7,770	$9.74	$11.55	$24,020
5	87902	Earth Drillers, Except Oil and Gas	1,020	$11.46	$12.16	$25,300
5	87905	Blasters and Explosives Workers	490	$9.98	$10.94	$22,760
5	87911	Rotary Drill Operators, Oil and Gas	3,300	$15.27	$17.18	$35,730
5	87914	Derrick Operators, Oil and Gas	5,920	$11.81	$12.80	$26,610
5	87917	Service Unit Operators	6,560	$10.20	$11.40	$23,710

RANK	OES Code	OES Title	1998 Employment	Median Hourly Wage	Mean Hourly Wage	Mean Annual Earnings
5	87921	Roustabouts	10,780	$8.68	$9.64	$20,040
5	87949	All Other Mining Machine Operators	300	$8.66	$9.47	$19,690
5	87989	All Other Extractive Workers	4,440	$10.82	$11.61	$24,140
5	87999	Construction/Extracative Wkrs. NEC	6,360	$10.39	$11.00	$22,880
5	89102	Tool and Die Makers	3,470	$16.97	$16.63	$34,590
5	89105	Precision Instrument Makers	160	$11.39	$12.33	$25,640
5	89111	Tool Grinders, Filers, Sharpeners	1,450	$12.85	$13.00	$27,030
5	89114	Pattern and Model Makers, Metal	230	$10.63	$11.95	$24,860
5	89117	Precision Lay-Out Workers, Metal	890	$13.19	$14.03	$29,180
5	89121	Shipfitters	910	$12.08	$12.41	$25,820
5	89123	Jewelers and Silversmiths	1,120	$11.35	$12.26	$25,500
5	89128	Precision Etchers and Engravers	110	$8.71	$9.63	$20,040
5	89132	Sheet Metal Workers	12,750	$10.96	$11.73	$24,400
5	89135	Boilermakers	2,420	$15.43	$16.01	$33,300
5	89199	All Other Precision Metal Workers	1,500	$11.12	$12.60	$26,220
5	89302	Pattern and Model Makers, Wood	420	$11.90	$13.01	$27,060
5	89305	Pattern Markers, Wood	50	$8.38	$8.86	$18,440
5	89308	Wood Machinists	1,830	$8.17	$8.63	$17,940
5	89311	Cabinetmakers and Bench Carpenters	6,580	$9.63	$10.30	$21,430
5	89314	Furniture Finishers	980	$8.34	$9.05	$18,820
5	89399	All Other Precision Woodworkers	580	$9.21	$9.53	$19,820
5	89502	Fabric and Apparel Patternmakers	570	$8.11	$9.45	$19,650
5	89505	Custom Tailors and Sewers	2,350	$7.70	$8.39	$17,450
5	89508	Upholsterers	1,920	$9.48	$10.02	$20,840
5	89511	Shoe/Leather Workers and Repairers	1,990	$7.21	$7.50	$15,610
5	89514	Spotters, Dry-Cleaning	670	$7.51	$7.80	$16,230
5	89517	Pressers, Delicate Fabrics	2,770	$6.65	$6.82	$14,190
5	89599	Precision Textile, Apparel Wkrs. NEC	660	$8.71	$10.18	$21,170
5	89702	Hand Compositors and Typesetters	450	$9.23	$9.50	$19,750
5	89705	Job Printers	990	$10.57	$11.27	$23,450
5	89717	Strippers	1,050	$14.58	$14.25	$29,640
5	89718	Platemakers	770	$12.32	$12.52	$26,050
5	89721	Bookbinders	170	$8.30	$10.59	$22,020
5	89802	Slaughterers and Butchers	7,500	$8.98	$8.64	$17,960
5	89805	Bakers, Manufacturing	2,750	$8.45	$9.05	$18,830
5	89808	Food Batchmakers	2,550	$7.80	$9.11	$18,960
5	89899	Precision Food/Tobacco Wkrs., NEC	410	$6.61	$7.65	$15,910
5	89902	Precision Foundry Mold/Coremakers	740	$10.42	$9.81	$20,400
5	89905	Precision Molders, Shapers, Casters	1,220	$11.50	$11.57	$24,060
5	89908	Precision Pattern- Model Makers	190	$10.06	$11.83	$24,610
5	89911	Precision Detail Design Decorators	170	$10.28	$10.61	$22,070
5	89921	Precision Dental Laboratory Technician	2,280	$10.92	$11.86	$24,670
5	89926	Gem and Diamond Workers	50	$11.98	$14.37	$29,880
5	89999	All Other Precision Workers	7,100	$12.37	$13.73	$28,550
5	91508	Combination Machine Tool Operator	1,340	$9.83	$10.62	$22,090
5	91914	Foundry Mold Assembly Wkrs.	680	$8.23	$8.78	$18,260
5	91938	Heaters, Metal and Plastic	270	$8.46	$8.90	$18,510
5	92197	Metal/Plastic Machine Setters, NEC	3,130	$9.06	$9.88	$20,550
5	92198	Metal/Plastic Machine Operators, NEC	4,930	$9.30	$10.18	$21,170
5	92305	Head Sawyers	230	$10.82	$12.00	$24,960
5	92541	Typesetting and Composing Setters	390	$10.84	$11.78	$24,510
5	92726	Laundry/Dry-Cleaning Machine Oper.	11,020	$6.32	$6.61	$13,760
5	92728	Pressing Machine Operators	6,830	$6.50	$6.85	$14,250
5	92917	Cooking Machine Operators	1,760	$7.41	$8.30	$17,260
5	92921	Roasting/Baking/Drying Machine Oper.	510	$9.80	$10.15	$21,120
5	92926	Boiler Operators and Tenders	680	$15.18	$15.57	$32,380
5	92947	Painters, Transportation Equipment	2,600	$12.34	$14.06	$29,250
5	92953	Coat/Painting/Spraying Mach. Oper.	4,250	$9.41	$9.97	$20,740
5	93105	Machine Builders and Assemblers	3,180	$12.61	$12.49	$25,980
5	93108	Fitters, Structural Metal	2,710	$11.89	$11.98	$24,920
5	93902	Machine Assemblers	3,230	$10.17	$10.68	$22,210
5	93911	Glaziers, Manufacturing	610	$8.99	$9.02	$18,770

RANK	OES Code	OES Title	1998 Employment	Median Hourly Wage	Mean Hourly Wage	Mean Annual Earnings
5	93914	Welders and Cutters	33,080	$11.88	$12.65	$26,310
5	93917	Solderers and Brazers	3,340	$7.91	$8.29	$17,250
5	93921	Pressers, Hand	1,230	$6.64	$6.80	$14,150
5	93923	Sewers, Hand	320	$7.57	$8.72	$18,130
5	93926	Cutters and Trimmers, Hand	2,390	$7.10	$7.66	$15,940
5	93928	Portable Machine Cutters	390	$8.31	$8.22	$17,090
5	93932	Carpet Cutters, Diagrammers	40	$8.62	$8.36	$17,390
5	93935	Cannery Workers	1,050	$6.71	$7.54	$15,670
5	93938	Meat, Poultry, and Fish Cutters	6,530	$8.20	$8.23	$17,120
5	93941	Metal Pourers and Casters	410	$9.98	$10.23	$21,270
5	93944	Molders and Casters, Hand	1,260	$7.28	$7.70	$16,010
5	93947	Painting/Coating/Decoratating Wkrs	1,920	$8.14	$8.88	$18,460
5	93951	Engraving and Printing Workers	840	$7.29	$7.57	$15,740
5	93953	Grinding and Polishing Workers	4,470	$8.16	$8.72	$18,130
5	93956	Assemblers/Fabricators, ex Machine	67,550	$8.20	$8.90	$18,510
5	93999	All Other Hand Workers	38,230	$7.56	$8.81	$18,320
5	97102	Truck Drivers, Heavy or Tractor Trailer	114,000	$11.57	$12.49	$25,970
5	97105	Truck Drivers, Light	76,920	$8.65	$9.37	$19,490
5	97108	Bus Drivers	16,970	$11.76	$11.56	$24,040
5	97111	Bus Drivers, School	22,100	$8.44	$8.61	$17,900
5	97114	Taxi Drivers and Chauffeurs	4,760	$6.90	$7.66	$15,940
5	97117	Driver/Sales Workers	19,190	$9.62	$9.80	$20,390
5	97199	All Other Motor Vehicle Operators	1,870	$7.63	$9.90	$20,590
5	97305	Locomotive Engineers	2,050	$19.42	$22.41	$46,610
5	97308	Rail Yard Engineers, Dinkey Operators	130	$16.98	$16.49	$34,300
5	97317	Railroad Brake, Signal Operators	630	$17.53	$18.76	$39,030
5	97505	Mates, Ship, Boat, and Barge	690	$15.70	$17.87	$37,170
5	97514	Able Seamen	770	$12.69	$12.11	$25,200
5	97517	Ordinary Seamen and Marine Oilers	1,140	$9.32	$9.88	$20,550
5	97805	Service Station Attendants	7,950	$6.68	$6.96	$14,470
5	97808	Parking Lot Attendants	5,130	$6.03	$6.75	$14,030
5	97899	All Other Transportation Workers	10,410	$12.98	$14.26	$29,660
5	97902	Longshore Equipment Operators	590	$22.63	$22.79	$47,400
5	97905	Tank Car and Truck Loaders	430	$18.40	$17.24	$35,850
5	97908	Oil Pumpers, Except Wellhead	2,050	$11.08	$16.66	$34,650
5	97911	Wellhead Pumpers	1,940	$17.91	$17.43	$36,250
5	97923	Excavating and Loading Machine Oper.	7,950	$10.41	$10.81	$22,490
5	97926	Dragline Operators	210	$11.28	$12.21	$25,400
5	97928	Dredge Operators	160	$9.75	$12.13	$25,220
5	97932	Loading Machine Operators, Mining	130	$8.59	$9.51	$19,790
5	97938	Grader, Bulldozer, and Scraper	8,220	$10.86	$11.43	$23,780
5	97941	Hoist and Winch Operators	1,490	$12.53	$13.10	$27,260
5	97944	Crane and Tower Operators	4,150	$13.73	$14.38	$29,910
5	97947	Industrial Truck and Tractor Operators	29,470	$9.63	$10.06	$20,930
5	97956	Operating Engineers	5,290	$14.42	$16.42	$34,150
5	97989	All Other Material-Moving Equip Ope	9,430	$9.36	$10.10	$21,010
5	97999	All Other Transportation Equip Oper.	4,020	$11.69	$12.31	$25,600
5	98102	Helpers, Mechanics and Repairers	19,690	$8.01	$8.49	$17,670
5	98311	Helpers, Brick and Stonemasons	4,730	$8.87	$9.05	$18,810
5	98312	Helpers, Carpenters	12,680	$8.69	$8.88	$18,470
5	98313	Helpers, Electricians	10,620	$8.89	$9.17	$19,060
5	98314	Helpers, Painters, Paperhanger	3,460	$7.91	$8.08	$16,800
5	98315	Helpers, Plumbers, Pipefitters	12,240	$8.49	$8.86	$18,440
5	98316	Helpers, Roofers	2,160	$7.51	$7.69	$15,990
5	98319	Helpers, All Other Construction	13,530	$8.22	$8.55	$17,780
5	98323	Helpers, Extractive Workers	1,020	$9.77	$10.25	$21,310
5	98502	Machine Feeders and Offbearers	9,220	$8.25	$8.65	$17,990
5	98702	Stevedores, ex. Equipment Operators	5,970	$12.66	$17.32	$36,030
5	98705	Refuse/Recyclable Material Collectors	4,490	$8.66	$8.92	$18,550
5	98799	Freight/Stock/Material Movers, Hand	58,160	$8.07	$8.55	$17,790
5	98902	Hand Packers and Packagers	62,170	$6.16	$7.01	$14,580
5	98905	Vehicle Washers/Equip Cleaners	21,090	$6.32	$7.03	$14,620

RANK	OES Code	OES Title	1998 Employment	Median Hourly Wage	Mean Hourly Wage	Mean Annual Earnings
5	98999	All Other Helpers and Laborers	130,760	$7.60	$8.19	$17,040
***	21302	Wholesale and Retail Buyers	6,540	$15.59	$17.63	$36,670
***	21305	Purchasing Agents/Buyers, Wholesale	1,620	$14.49	$16.43	$34,170
***	21308	Purchasing Agents, ex.Wholesale	16,130	$18.72	$20.54	$42,720
***	21911	Compliance Officers	13,500	$17.08	$19.21	$39,970
***	49002	Sales Engineers	6,330	$27.19	$28.16	$58,570
***	49008	Sales Representatives, ex. Scientific	86,230	$17.15	$19.82	$41,220
***	49034	Demonstrators and Promoters	3,760	$7.98	$8.79	$18,290
			8,847,570			