Sloan-LEHD Working Paper: The Industries

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The chapter is based on contributions from the Sloan Industry Centers: Financial Services (Larry Hunter), Retail Food (Elizabeth Davis, Brian McCall, Tim Park), Semiconductors (Clair Brown, Ben Campbell, and Greg Linden), Software (Kathryn Shaw & Eric Forister) and Trucking (Michael Belzer and Stan Sedo) .

Our five industries each have a unique history and distinguishing characteristics that mold the economic forces that they all share. Here we describe the important trends, including changes in industrial structure, technology, and regulatory regimes, that have shaped each industry during the past decade. This industry knowledge will help us understand why wage inequality, firm performance, and workers' career paths cut different swaths across industries in the following chapters.

Employment overview

Our five industries—financial services, retail food, semiconductors, software, and trucking—employed nearly 13 million American workers in 2002, ranging from half a million in the semiconductor industry, to nearly seven million in financial services. As Figure 1 shows, four of the five – all but the rapidly automating semiconductor industry – employ more American workers than they did ten years previous, with software growing most rapidly.

Semiconductor and software industries pay high weekly wages (median of $900 in 2002) and hire mostly men (nearly 70% of the workforce). Retail food stores pay low weekly wages ($300 in 2002) and hire men and women in about equal proportions. Financial services and trucking pay moderate weekly wages ($550 to $600 in 2002), but the financial service workforce comprises over 60% women, while the trucking workforce is over 80% male (Figures 2 and 3). Differences in the shares of racial minorities across the industries are not very pronounced (Figure 4), though the non-Whites in semiconductors and software are primarily Asian, and the non-Whites in the other industries are primarily Blacks and Hispanics.

Unions represent very few workers in financial services, software, or trucking. Collective bargaining plays a more important role in the retail food and trucking industries. Even in these two industries, however, the proportion of workers belonging to a union has declined precipitously over the past twenty years (Figure 5), so that no more than 20% of workers were represented collectively in either industry by 2002.

The education of the workforce has risen dramatically over the past two decades. During this period, the earnings of college graduates rose while the earnings of high school graduates stagnated These trends are also evident in our five industries, although with some differences across the industries. Among less-educated workers (high school or less), earnings are as high in trucking as in the high-tech industries, semiconductors and software, and are less volatile, while earnings in banking are catching up. Earnings of less-educated workers in retail food are substantially lower than in the other four industries, and earnings in trucking and food stores are stagnant over the twenty year period.

Meanwhile highly-educated workers (college graduate or more) in the five industries experienced increasing real weekly earnings at least since the late 1990s. However these workers' earnings grew faster in semiconductors, software, and financial services than in trucking or food (Figure 8). From the mid-1980s to the mid-1990s, inequality increased noticeably in three industries—semiconductors, software, and financial services; it rose only slightly in trucking, and actually fell in retail food. (See Figure 9, the ratio of the 90^{th} to10^{th} percentile earnings, or the highest to lowest paid workers).

With these overall trends in earnings, education, and inequality in mind, we turn now to sketches of each of the five industries, especially over the period 1992-2002. We begin with the lowest-paying sector, retail food, and move through the industries to the highest-paying sector, software.

Retail Food

The retail food industry saw major changes both in market structure and in competition during the 1990s. The industry, as defined for this study (and consistent with NAICS),[1] includes both traditional food stores such as supermarkets, grocery stores, specialty food stores such as bakeries or meat markets and convenience stores, and non-traditional retailers including supercenters and warehouse clubs.[2] In 2002, the 224,300 food stores in the United States sold nearly $450 billion worth of food and nonfood products.

Though food retailing had traditionally been a highly competitive industry with thin operating margins, the 1990s featured dramatic changes in the landscape of food

[1] Some definitions of the retail food industry include the food service industry, e.g., restaurants. For the purposes of this study, food service is not included in the industry definition.
[2] A supercenter is defined by The Food Institute as a large food/drug store combined under one roof with a mass merchandiser where food items account for as much as 40% of the selling area.

retailing which further heightened competition. During this period, an increasing number of retailers from outside the traditional food industry began to compete with supermarkets to sell both food and nonfood items. Such "power retailers" included mass merchandisers (Wal-Mart, Kmart and Target, for example), warehouse club stores (such as Costco, Sam's Club and BJ's Wholesalers), and other retailers such as drug stores (e.g., Walgreen's) and dollar stores. In fact, Wal-Mart is now the largest food retailer in the United States.

The rapid expansion of mass merchandisers and warehouse club stores was accompanied by relatively slow growth in sales at supermarkets, about one percent per year after adjusting for inflation. Supermarkets' share of food sales fell, while the share of food sales accounted for by mass merchandisers, warehouse clubs and other non-traditional food retailers more than doubled from 9% in 1994 to 19% in 2002. (The Food Institute, 2003).

Traditional food stores also faced more competition from another source: restaurants and other foodservice companies. Many food stores altered their size, format, and product line to respond to these forces. Individual food stores have grown larger, expanded offerings of ready-to-eat, organic and natural food products, offered more nonfood items and services, lengthened hours of opening, and adopted various technological innovations to streamline both back-end and frontline operations.

Like most retailers, food stores (and nonfood stores that sell food) are characterized by a flat or bottom-heavy job hierarchy, with large numbers of clerks, cashiers and stockers, and relatively few managers. The job structure became even more bottom heavy as executive, administrative and managerial jobs declined 30 percent between 1983 and 1993 (Moody, 1997). This bottom-heavy job structure combined with a prevalence of part-time workers

helps explain the low average wages in the retail food industry—average weekly earnings were only $365 in 1984, and increased slightly to $384 in 2002 (in $1998). The number of weekly hours worked per employee is lower in retail food than in other industries (around 35 hours per week, compared with 40 or more in other four industries).

Wage inequality changed little during the 1990s in the retail food sector. The Gini coefficient remained nearly unchanged over the time period, though the $90^{th}/10^{th}$ and $75^{th}/25^{th}$ ratios declined slightly. These declines were attributable to increases in real earnings at the bottom end of the wage scale accompanied by declines at the top. The level of human capital and returns to education are generally low in this industry, and there is little evidence of changes to these over the decade. Thus changes in technology did not translate into increased returns to human capital or to increased wage inequality in retail food.

Budd and McCall (2001) find that real wages decreased in grocery stores in the period 1984-1994 but that this downward shift in the wage distribution was not accompanied by a consistent increase in wage inequality over the time period. Budd and McCall attribute these changes in the wage distribution in grocery stores primarily to erosion of the minimum wage, with some importance given to declines in union density and in the union wage premium.

Retail industries, including food stores, are generally not known for innovative or high-performance human resources practices. Indeed, the typical food retailer maintains a hierarchical and centralized approach to labor (Ben-Ner et al., 1999). Anecdotal stories abound of store managers and executives who have worked their way up, but the actual level of upward mobility is constrained by the small number of managerial positions and by lack

of training opportunities. One study of supermarkets found that while department heads are often hired from within, store managers are not (Walsh 1993). Over the past several decades, the predominant type of job in the supermarket industry has changed from a full-time, relatively well paid position (often unionized), to a job with irregular and part time hours, low pay, and few options for training and career advancement (Hughes 1999).

Substantial technological change has occurred in the retail food industry, but it is generally not "skill-biased" toward higher skilled workers. The near-universal adoption of scanning technology by the early 1990s may have increased the productivity of low-skilled workers like cashiers. Labor productivity in the retail food industry remained virtually unchanged between 1992 and 1997, and the dispersion of productivity increased only slightly. This trend contrasts with the previous decade when labor productivity in food stores fell 13 percent between 1983 and 1993, which partly reflected increased use of labor-intensive services such as in-store bakeries and delis, and longer opening hours (Moody,1997). Since 1997, labor productivity in retail food has begun to rise, perhaps as a result of improvements in efficiency after mergers and consolidation (Kaufman, 2002).

Retail food businesses increasingly use information technology in supply chain management, with growing adoption of electronic data interchange (EDI) technology. Food retailers also are experimenting with additional in-store technologies, such as self-checkout systems and electronic shelf tags. King and Park (2003) find store-level productivity gains associated with adoption of information technologies such as vendor-managed inventory and frequent shopper/loyalty card programs. Rates of technology adoption tend to be higher among stores in self-distributing groups, which operate their

own warehouses and distribution networks, compared to stores supplied by independent wholesalers.

The 1990s also featured consolidation. Market shares held by leading food retailers rose markedly: between 1997 and 2000, the four largest food retailers' share rose from 18 to 27 percent of total grocery store sales in the United States. The number of mergers and acquisitions peaked in the late 1990s as some chains chose to grow through acquisitions, while others (Wal-Mart in particular) continued to open new stores. Two of the largest events in retail food consolidation occurred in 1998: the joining of the fourth and second largest food retailers (Albertson's and American Stores), and top-ranked Kroger's purchase of sixth-ranked Fred Meyer (ERS, 2000). Foreign ownership of food retailers also increased over this period, with recent figures indicating that about 15% of grocery stores sales are accounted for by foreign-owned companies (Kaufman 2002).

While many retail food chains operate in multiple markets, for most stores and their consumers the relevant level of competition is local. Concentration of food retailing has also been increasing at the local level, however. A study of the 100 largest cities in the U.S. found that the largest four firms accounted for an average of 72 percent of supermarket sales in 1998, up from 69 percent in 1992. The continued expansion of large nonfood retailers like Wal-Mart into new regions will continue to put pressure on food retailers to cut costs and increase efficiency.

Increased concentration in the retail food sector has been associated with higher profits, but the impact of concentration on pricing and wages is less clear. Studies find both positive and negative relationships between prices and concentration (Kinsey 1998, Simpson and Hosken 2000). Concentration may lead to higher prices through the exercise

of monopoly power, yet may also result in lower prices because of efficiency gains in distribution networks and greater bargaining power with suppliers. Competition from non-union retailers, through both mergers and acquisitions or through expansion into new markets, may place downward pressure on wages at traditional food retailers, but there has been little research to date on these trends. What is clear is that the traditional retail food sector will continue to face intense competitive pressures due both to changing consumer preferences and the expansion of other retailers into food sales.

Trucking

In 2002 the trucking industry consisted of 113,237 establishments employing 1,826,000 workers with revenue of $169 billion. This compares with 110,908 firms, 1580,095 employees and $143 billion in revenue in 1992. However, these figures underestimate the contribution of truck transportation to the overall economy, since they include only the employees of the so called 'for hire' firms within the industry. This excludes trucking operations that occur within other industries, such as manufacturing and retail, as well as the self employed 'owner operators'.

The industry has changed greatly in the past 25 years, since economic regulations were lifted and interfirm competition intensified. Before deregulation, the industry consisted primarily of regulated common carriers which were certificated by the Interstate Commerce Commission (ICC) to haul specific commodities between specific city pairs, and contract carriers, permitted to haul under contract for up to eight shippers. Following deregulation (which began administratively in 1977 and was written into law in the Motor Carrier Act of 1980), the shape of the industry changed dramatically. Upon

deregulation, market-driven differentiation separated the carriers by freight shipment characteristics, into truckload (TL) and less-than-truckload (LTL) markets, which by the middle of the 1980s, no longer competed with each other (Belzer, 1994).

The trucking industry had been considered nearly completely unionized in the 1970s (Levinson, 1980), including the truckload industry (Schneider Transport is a good example), and specialized industries ranging from steel hauling and dry and liquid bulk hauling to car hauling. After deregulation began, however, the attrition of common carriers and intense competition led to a substantial decline in union density in many markets. The recession of the early 1980s, and its resulting loose labor market, put pressure on both carriers and workers to haul freight for less. New, non-union truckload carriers paid low wages, little or no health insurance cost, and almost never contributed to drivers' pension plans, so that "legacy costs" were overwhelming to the old-line carriers. Older, unionized firms exited in record numbers, firm death was rapid and the birth of new non-union firms changed the complexion of the industry quickly. Indeed, most of the carriers that had existed since the days of horse-drawn teaming were out of business by the end of the first decade of deregulation (Weintraub, 1992). In 2002, only car-haul remains as a generally unionized specialized market (much of this due to the unusual skills and equipment required, as well as to the value of the freight hauled).

Competition also led to a growth in subcontracting which, in turn, fueled deunionization. Many non-union carriers did not have the capital to expand, but they found those assets in owner-drivers who leased their trucks to them. In addition, individual owner-operators now could easily apply for and receive 48 state authority, and today about 300,000 drivers own their own trucks (though 80 percent are leased

"permanently" to motor carriers under whose authority they operate). Indeed, as unionized trucking jobs disappeared, many experienced drivers bought their own trucks and attempted to compete in this market by undercutting the rates of existing carriers, and further cutthroat competition ensued. The Teamsters Union was built substantially on owner-operators: Roadway, one of the largest unionized LTL and Master Freight carriers, was an owner-operator company until the mid 1950s. But under the current interpretation of the law, these drivers are not allowed to unionize (Belzer, 2002).

The industry structure changed further after 1995, when intrastate trucking was deregulated. These changes intensified the competitive effects wrought by deregulatory policies some two decades previously. In 1994, Congress mandated the deregulation of intrastate truck transportation. Until that point many states (especially key large states such as California, Texas, Michigan, and Pennsylvania) retained regulation for intrastate trucking, protecting local cartage within those states, which date "deregulation" from 1995, when the competitive wave hit them. Beginning in 1995 in regional LTL and in local cartage, union wages and benefits became increasingly untenable. At the same time, new and small non-union LTL carriers took advantage of new opportunities and grew rapidly.

The CPS shows that for all truck drivers (including local markets and those operating relatively smaller trucks), the average earnings is $7.01 per hour and those working more than the 60-hour legal limit average $6.20 for each hour worked (Belzer et al, 1999). While there was a small increase of about 3.6% in mean weekly earnings between 1992 and 1998, there was no increase in the median. The ratio of earnings between the 90^{th} and 10^{th} percentiles increased slightly between 1992 and 1998, but

earnings inequality remains low relative to other industries. Wage inequality patterns in trucking may depend in part on hours worked, however, since drivers focus on their target earnings and tend to extend their work week to make up the difference. The majority of all over-the-road truck drivers work more than the legal limit (Belzer 2000).

Opportunities for advancement within a company are limited in trucking. While longer tenure may result in favorable schedules or routes, these are marginal improvements, at best. The most common route to better earnings and working conditions is to change companies altogether. However, even this strategy has become increasingly limited with the decrease in the number of available union jobs over time.

The lack of returns to tenure in trucking are a primary cause of the high turnover rates in the trucking industry. It is not unusual for firms to have turnover rates in excess of 100% per year. These excessively high rates of turnover result in greater hiring and training costs that are a major concern within the industry. For example, J.B. Hunt, one of the nation's three largest TL carriers, began a bold experiment in paying for experience when it raised driver wages by 38% in 1997, partly in response to a documented 96% turnover rate (Belzer et al. 2002). The resulting improvements in worker quality and retention rates improved both productivity and profits for the company. Despite the success of this strategy, the changes made by Hunt remain the exception rather than the rule in the trucking industry, and provided only a temporary respite for the industry's perceived "driver shortage."

In sum, the consequence of these long run changes has been the transformation of truck driving and dock work from good jobs – paying better than average wages and excellent benefits – in the 1970s to bad jobs by the 1990s, paying low wages and little or no

benefits. The industry went from majority-unionized in the mid 1970s to less than 20% unionized today, and union density of over-the-road drivers has dropped to about ten percent. In 1997, the average over-the-road driver worked about 65 hours per week and about 3400 hours per year for about $10 an hour (Belzer, 2000) If these drivers were covered by the maximum hours rules in the FLSA, their hourly wage would come to about $8.50 per hour. In local markets these drivers earn even less (Belzer, 2000).

Financial Services

Financial services have grown rapidly from 6.4% of the U.S. Gross Domestic Product in 1992 to 8.6% in 2001. Financial services comprise three main categories; depository institutions and lenders (such as banks and savings and loans); securities and commodities firms; and insurance firms (including carriers, brokers, and agencies).

Once heavily sheltered from competition, encumbered by regulation and bureaucracy, the American financial services environment has become increasingly dynamic. Deregulation is a key to understanding recent environmental change in the industry, and is typified by two key pieces of legislation. The Interstate Banking and Branching Efficiency Act of 1994 (also known as the Riegle-Neal Act) completed the deregulatory process of extending branch banking across state lines. Five years later, the Financial Services Modernization Act of 1999 (a.k.a. Gramm-Leach Bliley) formally repealed restrictions imposed by the 1933 Glass-Steagall Act. Glass-Steagall, a remnant of the New Deal-era, had been under siege for years. Its provisions formally barred banks, brokerages and insurance companies from entering each others' industries, and separated investment banking from its commercial counterpart. Throughout the 1990s

financial services firms increasingly sought economies of scale and scope, and cross-market opportunities, challenging Glass-Steagall limits; in fact, Gramm-Leach-Bliley served in part to realign statutes with changes in the industry.

Rapid technological advances have accompanied deregulation; indeed, these advances underlay many of the pressures that led to regulatory change. In retail financial services, for example, the proliferation of Automatic Teller Machines (ATMs), and telephone, home, and PC-based banking, provide alternative channels for customers, while new back-office technologies have dramatically decreased the costs of handling individual accounts and transactions. Generally, financial services account for a disproportionately large share of IT investment in the economy (Hitt, Frei, and Harker, 1999).

Technology and deregulation combine with the changing desires of consumers to create enormous pressure for changes in financial services. Consumers demand anytime-anywhere delivery of financial services along with an increased variety in deposit and investment products, and are moving away from the use of checks to other financial products only slowly. Most consumers still frequent bank branches, and "mixed channel consumers," those that use multiple delivery points, are now the norm (Frei et al. 1999).

The 1980s and early 1990s had featured unprecedented turbulence in financial services, and especially banking (Berger, Kashyap, and Scalise 1995). Though the 1990s saw no equivalent to the Savings and Loan scandals and difficulties of the 1980s, the recent era has been characterized by increasingly fierce competition and rapid change. A central feature of the industry is consolidation. For example, the high-water mark for the number of FDIC-insured commercial banks was reached in 1984, when there were

14,496 banks in the U.S. By 1992 this number had dropped to 11,466 and by 2002 the U.S. had only 7,887 banks, even as the number of bank branches has grown substantially (from 51,935 in 1992 to 66,185 in 2002.) Especially precipitous has been the drop in small institutions: the number of single-unit banks dropped in half between 1992 and 2002 (from 4,647 to 2,319).[3]

Cross-industry consolidation, particularly among large firms, has also accelerated. For example, Chase Bank, itself the product of mergers between Chase Manhattan and Manufacturers Hanover in 1991, and between Chase and Chemical in 1996, merged with the investment bank J.P. Morgan in 2000 to form J.P. Morgan Chase and Co., which in turn announced its intent to acquire retail giant Bank One in early 1994. Citigroup, similarly, is a product of a 1998 mergers between Citibank and Travelers Insurance, which itself had earlier acquired the investment bank Salomon Smith Barney (in turn, a product of mergers between investment houses Smith Barney and Salomon Brothers).

Over the past twenty years, the composition of the financial services workforce has shifted toward more educated workers. In part, the displacement of lower-educated workers reflected technological changes that reduced the number of workers needed in positions such as tellers, clerks, and transactions processors. One place this can be seen is in the shift in the sex composition of the workforce: despite the increasing share of women in the labor market in this period, the share of women employed in financial services actually dropped from 65% to 62% between 1984 and 2002, as the mix of jobs shifted away from those traditionally held by women.

Technological changes, however, do not explain the entire shift in composition. The absolute number of tellers employed in financial services, for example, has declined

[3] Data taken from FDIC and available at http://www.fdic.gov.

very little, and not nearly as rapidly as BLS projections had anticipated for most of the period. Rather, the educational requirements for particular jobs have in some cases been upgraded. Many banks now seek tellers and other customer service representatives with higher levels of education, even college degrees, and expect them to incorporate sales work and other more advanced kinds of customer service into their jobs (Hunter et al 2001).

Overall earnings inequality in the industry, as measured by the Gini-coefficient, grew steadily between 1984 and 1989, was relatively stable between 1989 and 1998, and then grew further from 1998 to 2002. Nearly all of this action was driven by increases in the earnings of the highest-paid. Real earnings for high school graduates in financial services rose only 1% between 1984 and 1994, while during this same period college graduates saw increases of about 9%. Between 1994 and 2002, however, real earnings for college graduates rose another 20%, while high school graduates experienced real increases of 10% during this period. In 1984, college graduates in financial services earned on average 1.8 times what high school graduates earned. By 1994 this gap had grown to 1.98, and by 2002, to 2.15.

Concurrent with these earnings trends was the destruction of long-standing internal labor markets and career ladders in the industry. Financial services firms, especially local banks, insurance agencies, and the like, had long provided opportunities for workers with relatively little education to enter organizations, gain skills, and to advance over time to well-paying positions. Such advancement became increasingly rare over the period, as segmentation between jobs with different educational requirements sharpened dramatically (Hunter 1999). High school graduates, and workers with some college education, found their

routes to advancement blocked, particularly in larger organizations, as formal educational requirements began to replace industry and firm experience as prerequisites for high-earning jobs. This trend was intensified by the frenetic merger activity in the banking industry, as small, locally owned firms were purchased by larger companies, local managerial jobs such as those in branches were devalued, and firm experience was decreasingly valuable (Skuratowicz and Hunter 2004).

Financial services has served as a canonical example of the so-called "productivity paradox," in that it has been difficult to find positive results associated with restructuring and the industry's massive investments in information technology. In part this is because productivity in financial services is notoriously difficult to measure. The Bureau of Labor Statistics and others have not converged on satisfactory indicators equivalent to revenue per worker, value-added measures, or other kinds of

It is also true that innovations in financial services have accrued to customers in ways that have been difficult for organizations to measure. For example, speed in processing loan applications, 24-hour availability of fund for withdrawal, or ease in moving money across accounts may not be captured in traditional output measures (Frei, Harker, and Hunter 1999). Further, much of the efforts toward which technology and human resources are directed involve outputs that reflect aspects of quality services that are relatively difficult to measure. Finally, the nature of financial services products (such as insurance, and loans) suggest that the value to firms and customers of the services that financial firms deliver is revealed only over time, and often with substantial lags.

Despite the difficulties associated with measuring productivity, however, it has for some time been clear that some financial services firms are more efficient than others.

For example, the consensus among researchers in the banking and credit-union industries in the 1990s was that differences across firms in "X-efficiency," the technical or allocative efficiencies not attributable to size or scope, were relatively large, and dominate scale and scope efficiencies (Fried, Lovell and Vanden Eeckaut, 1993; Berger, Hunter and Timme, 1993; Berger and Mester 1997).

Semiconductors

The semiconductor industry develops and produces semiconductors (or "chips"), the electronic devices that provide functionality to an ever-widening array of products. The industry, with a global output of $180 billion in 2003, is characterized by rapid technological change, high capital and research costs, continual price declines, and exacting quality standards. These characteristics result in high risks and potentially high returns. The semiconductor industry is deeply competitive both in the short run (that is, the typical 18-month product cycle) through price reductions and in the long run through the introduction of new and better products. Increased automation has limited employment and kept skill requirements high even as the industry has expanded.

Through the 1970s, semiconductor firms were all vertically integrated. The industry's history since then is a story of steady dis-integration as specialized sub-industries, such as those for manufacturing equipment ($25 billion) and design software ($4 billion) have emerged.

Semiconductor manufacturing involves three distinct stages – design, wafer fabrication, and assembly. The first stage to arise as a separate industry was the backend assembly of the fragile wafers into sturdy packages that can be inserted into equipment.

US companies began moving their labor-intensive assembly operations to lower-cost locations as early as the late 1960s. Local firms, especially in Asia, took over many of these operations on a contract basis and now dominate the assembly industry, which today has only a small presence in the United States.

Chip design emerged as a separate industry during the 1980s. “Fabless” companies design chips and then contract for fabrication by other chip companies. Chip design has also been part of the ongoing debate about offshore outsourcing. The fabless design industry, accounting for over 10% of chip revenues, got a big boost with the appearance in the 1990s of independent wafer fabrication companies (“foundries”), which do not design and sell chips of their own. Chip designers no longer feared sending designs to a possible competitor for fabrication. The foundry model was pioneered in Taiwan, which is still home to the largest share of the $12 billion foundry industry. The US, where the chip industry was born, remains home to about a third of fabrication capacity (Leachman and Leachman, 2004).

The competitive positions of firms and countries in the semiconductor industry have undergone dramatic changes since 1980, when IBM introduced its first personal computer. In the mid to late 1980s, Japanese firms used their manufacturing excellence to grab the lion’s share of the market for the memory chips (DRAM). But the 1990s saw the resurgence of US firms, led by Intel, based on improved production methods and product innovation as well as the dominance of the personal computer, or PC (Macher, Mowery, and Hodges, 1998). The 1990s also witnessed the rise of Taiwanese foundries, which manufacture chips designed by other companies, and which spurred the growth of new fabless design companies, especially in the U.S. Widespread adoption of the

Internet and introduction of wireless devices challenged the central role of the PC and allowed chip producers from Europe and Asia to gain ground. Further upheaval is to be expected with the entry of China to the global industry. (Linden, Brown, and Appleyard, 2004). In 2003 U.S. firms accounted for about 50% of the global market. This includes Intel's 20% share and the fabless companies' 10% share.

With the rise of the fabless-foundry model, the industry includes small competitive firms alongside large multinational integrated corporations. This diverse group of firms uses employment systems that range from competitive spot markets to traditional internal labor markets. Fabless start-ups often have competitive, short-term employment relationships that are project-related, and offer high-risk, high-return compensation packages. Multinational corporations offer more secure long-term employment relationships with structured career ladders. Even these secure employment relationships weakened in U.S. companies throughout the 1990s, as some older companies experienced hard times early in the decade and as the mobility of engineers increased with the lure of huge profits from stock options if their start-ups became publicly traded or acquired during the boom late in the decade.

The automation of chip manufacturing along with the outsourcing of manufacturing to Asian foundries resulted in American semiconductor employment becoming even more dominated by highly-skilled engineers, as operators became a shrinking part of the workforce. College graduates rose from 42% of the workforce in 1985 to 57% in 2002; workers with a high school diplomas (or less) declined from 33% in 1985 to 18% in 2002. Overall earnings inequality increased in the industry over this

period, reflecting the increase in returns to education, with the earnings of college grads rising more than the earnings of high school grads.

Although the semiconductor industry is an engine of growth for the economy, this industry relies upon highly-educated engineers. The fabless firms are growing much faster than integrated firms, many of whom are outsourcing some manufacturing to foundries (called “fab lite”). We should expect the trend toward engineers and away from operators to continue. However we do not expect employment to grow as fast as revenues. The semiconductor industry will not be a major source of new engineering jobs in the future, and we expect overall employment to be affected by current trends in off-shoring.

The aggregate earnings trends in the industry are not reflected within manufacturing plants. A detailed study of a small sample of fabs showed that earnings for engineers deteriorated and that returns to education did not increase during the 1990s. Inequality across occupations actually decreased with more advanced technology. Career ladders, as measured by the ratio of maximum pay to initial pay for an occupation, are flatter for engineers at the more technologically-advanced fabs. Career ladders for operators remain the same, and career ladders for techs improve slightly. In contrast, career ladders are steeper in fabs with older technology. (Brown and Campbell, 2001)

Productive career paths also take workers in the semiconductor industry across firm boundaries. Campbell (2004) shows that professional workers who join fabless start-ups fare better than their counterparts who work for established firms. After five years, employees who have joined start-ups have earned a total of approximately $50,000 more at the median than comparable workers who change jobs from one established firm to another. (Campbell, 2004).

Software

Innovation in information technology (IT) has transformed the U.S. economy. Every application of IT has required software. Initially, software production was dominated by hardware producers and firms that were the end users. Over time, software production has shifted away from these two groups towards independent software vendors (ISV). The software industry has matured and this has recently brought about structural change as the production of software has been automated or outsourced overseas to sources of cheaper labor (Ellis and Lowell, 2003).

Before the late 1960s, most software companies were small, reliant on government contracts and system development work from hardware companies, focusing on development of high-level languages such as FORTRAN or COBOL, and on development tools, such as debugging and automatic test data generation. During the late 1960s, however, an independent software industry began to arise and the contemporary era of the software industry can be dated to the early 1980s (Endres, 1996; Steinmuller, 1995).

The introduction of the personal computer brought with it mass market software publishing. During the 1980s, firms' software development needs were increasingly contracted out to specialists, reflecting the growing complexity of data processing technologies as well as a rising trend by firms to contract out many types of services. At this same time, single software products were becoming de facto standards for specific applications, reflecting the network externalities in the software market. However, the very fast rate of technological change in computing and software also tended to make the dominance of specific software products more transitory. The market for programming

services, software products, and professional services grew to $68 billion in 1988, to $155 billion in 1995, and then skyrocketed to $357 billion in 2001 (Bureau of Economic Analysis, U.S. Census Department, Industry Economics Division).

The diversity of industries that use software in the U.S. has made it difficult for computer manufacturers to pursue vertical market strategies. Most hardware vendors have retreated from software production or reduced their reliance on it. For example, IBM strongly emphasizes their advantageous collaboration with ISVs.[4] Furthermore, recent entrants into computer production are minor participants in software production, owing to the large amount of ISVs. The prior existence of enormous numbers of small contract programming companies directly led to the current large number of ISVs. Among computer producers, ISV participation has fostered greater product diversity and faster sales growth than producers would have realized from their own in-house production of hardware and software. Moreover, for end users of software, the ISV use also presents an important cost-reducing alternative to internal production of software. These changes are reflected in the rapid growth of software vendors, such as the growth of Oracle, People Soft, and SAP.

Employment in the software industry increased nearly fivefold between 1984 and 2002, doubling in the period since 1992. In some ways, this understates the size of the industry, because virtually every company involved in information technology, from hardware producers to end users, writes software. Measurement of the industry's activity via sale of software services and packaged software does not include the investment in software creating activities within organizations. The magnitude of these activities is indicated by the fact that more programmers are employed outside the business service

[4] For an example, see http://www.developer.ibm.com/tech/isvadvantage.html .

(which includes software) industry than within this industry. In 2002, according to the Bureau of Labor Statistics, only 81,000 computer programmers and software engineers worked in the software publishing industry, out of over one million total computer programmers and software engineers (BLS, 2003).

The two main professions dedicated to the creation of software are software engineers and software programmers. Programmers write programs according to the specifications given to them. Programmers also modify existing programs in order to update, expand, or repair them. Software engineers design, develop, test, write, and evaluate software programs. Software engineers must possess strong programming skills, but are more concerned with developing algorithms and analyzing and solving programming problems than with actually writing code (Ellis and Lowell, 2003). Professional certification for software engineers is now offered by the Institute of Electrical and Electronics Engineers (IEEE) Computer Society, and the number of certifications available to IT workers doubled from 200 to 400 between 1997 and 2000. With short product cycles, and many vendor-specific certifications requiring continual updating, the profession sees value in standards-based certification.

CPS data show that median annual earnings of computer programmers were $60,290 in 2002. Median annual earnings of computer applications software engineers who worked full time in 2002 were about $70,900. As of 2003, computer programmers are overwhelmingly white (76%) and male (72%). The same was true of software engineers, with 66% being white and 75% being male. In 1996, nearly 80% of computer programmers were under the age of 45. Earnings inequality in the industry, as measured

either by the 90-10 earnings ratio, or by the Gini coefficient, increased from the mid-1980s to the late 1990s.

Computer programmers and software engineers are employed in almost every industry, but the largest concentration are in computer systems design and related services. A large concentration of programmers also work in software publishing. A large number of programmers and software engineers are employed on a temporary or contract basis. This is because companies demand expertise with new programming languages or with specialized areas of applications. We cannot quantify the extent of this contracting out. However, note that about 21,000 out of 675,000 software engineers were self-employed in 2002, which is a relatively high share for white-collar occupations (U.S. Department of Labor, 2003).

Technological change has played an important role in the evolution of the industry. With the growth of personal computers since the 1980s with CRTs, the emergence of Graphical User Interface (GUI) tools made it easier for end users who were not primarily programmers to satisfy some of their own programming needs. The further development of CASE tools, which check for programming errors, meant that many of the lower-level programming tasks that software engineers would have assigned to programmers could now be automated. Over time, the nature of programming has changed, so that programs are written in modules, rather than as completely intertwined in-house products. As all of these changes improved the design methodology, programming could be more easily specified and contracted out or outsourced overseas (Endres, 1996). Outsourcing overseas grew from $300 million in 1995 to $1.2 billion in

2001 as measured by imports of IT services (Ellis and Lowell, 2003)[5]. While this growth rate is dramatic, it must be considered in the context of U.S. industry growth: it remains at only .3% of domestic output.

There has recently been a great deal of controversy regarding the shortage of IT workers in the US. One response to the shortage claimed by the IT industry was a temporary increase in the number of temporary foreign worker (H-1B) visas.
A recent study sponsored by the Alfred P. Sloan Foundation, however, casts doubt on the extent of such a shortage (Ellis and Lowell, 1999). The number of computer programmers rose from under 400,000 in 1983 to a peak of over 600,000 in 1997. Since then, structural reductions in demand for computer programmers, coupled with recent cyclical changes in demand (including the dot-com crash), resulted in a reduction of employment of computer programmers to 499,000 in 2002, with the number rebounding to 563,000 in 2003 (BLS, 2004). The modest growth is the net result of many countervailing developments in the industry: not just offshore contracting, but the introduction of advanced, object-oriented, programming languages; "embedded" programming skills among end users; and automation of code writing.

At the same time, the demand for the best programmers who have superior creativity, ingenuity of design, or problem-solving abilities has increased dramatically. For programmers, the level of education and experience employers seek has been rising, due to the growing number of qualified applicants and the specialization involved with most programming tasks. Employers are primarily interested in programming knowledge, and computer programmers can become certified in a programming language such as C++ or Java. 49 percent of computer programmers had a bachelor's or higher degree in

[5] Data drawn from U.S. Department of Commerce Bureau of Economic Analysis.

2002 (U.S. Department of Labor, 2004). And while the demand for programmers has been flat or declining, the demand for software engineers, systems analysts, and computer scientists has grown dramatically. From under 350,000 in 1983, the number peaked at about 1.9 million in 2000, but has only dropped down by 50,000 since then to 1.85 million.

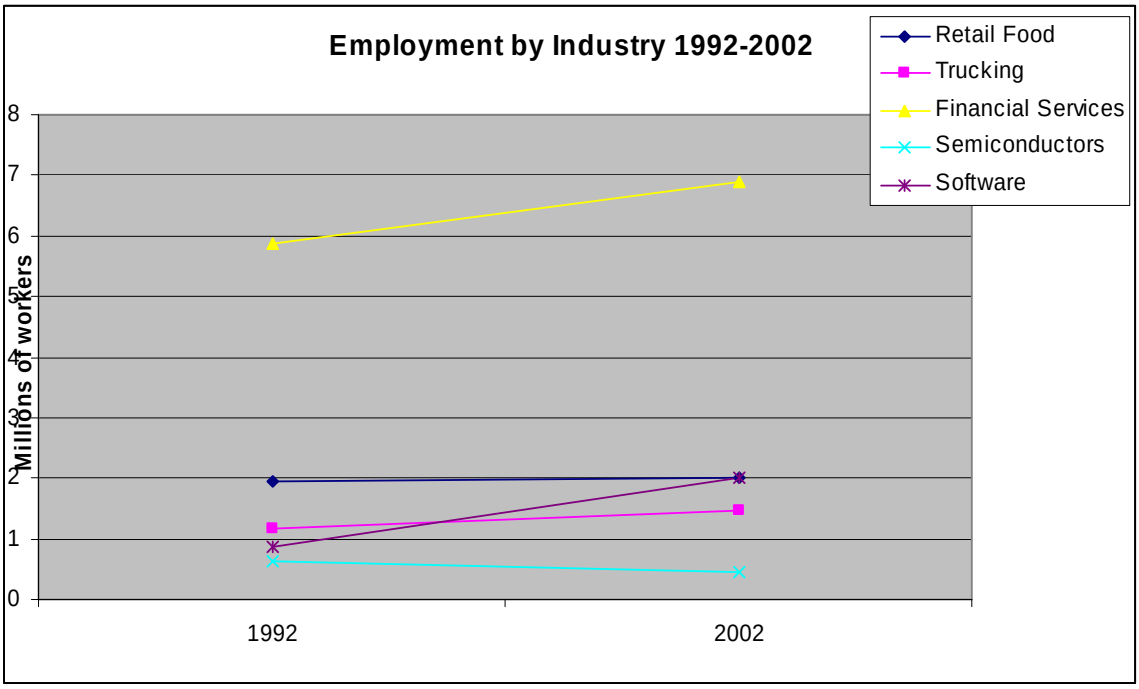
Employer interest in programming knowledge is reflected by the fact that having the opportunities to gain critical skills through job assignments was one of the top responses of IT workers to an *Information Week* salary survey. The importance of having knowledge of and experience with the most current programming languages is supported by the anecdotal evidence that middle-age technical workers have difficulty finding IT jobs, since a large part of their experience may be with obsolete languages that are no longer in demand.

Summary

Our LEHD studies put five industries under the microscope: financial services, semiconductors, software, retail food, and trucking. The industries span the economic spectrum, from manufacturing to service, from low technology to high technology, and from low wage to high wage. Each has been buffeted by some combination of globalization, deregulation and changing competition, and technological change. But not only is it difficult to measure directly globalization, outsourcing, technological change and deregulation. Because each of these factors has a different effect on different industries, using broad-brush aggregates to describe the impact is misleading. Here we have used industry-study evidence to describe the changes that have occurred in each

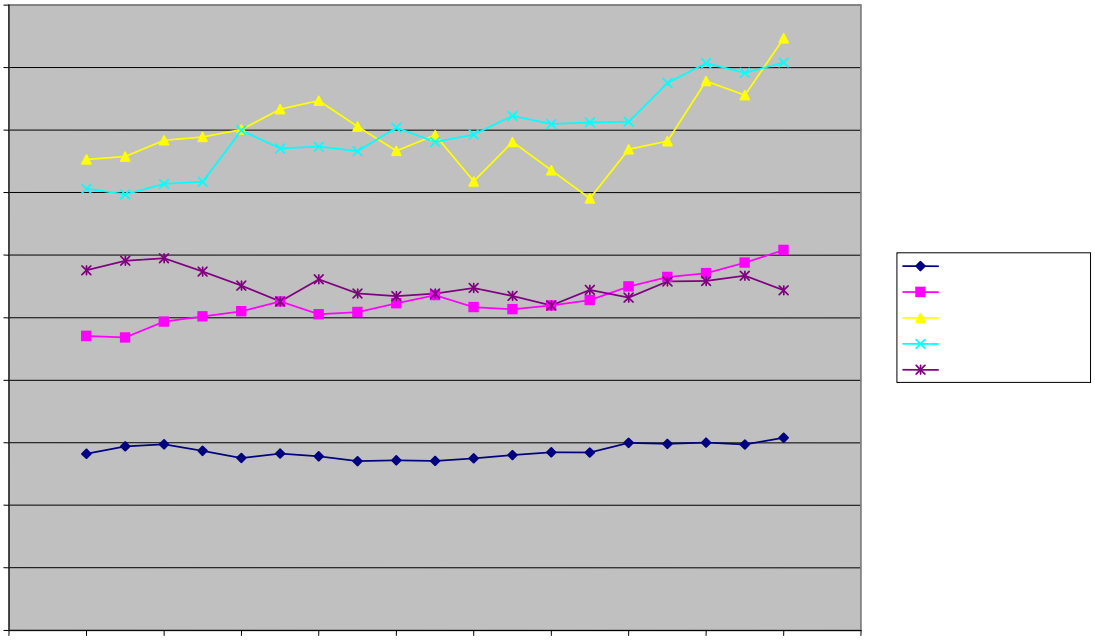
industry over time, suggesting that these industries be seen as a microcosm of the broader economy. Further LEHD studies quantify and examine the implications of economic turbulence on how firms perform, how they structure their jobs, and how workers fare in their careers.

Figure 1
Employment by Industry



Industry	Total Employed (millions)	
	1992	2002
Retail Food	1.94	2.01
Trucking	1.18	1.48
Financial Services	5.86	6.89
Semiconductors	0.62	0.45
Software	0.86	2.01

Figure 2



Data from Current Population Survey.

Figure 3

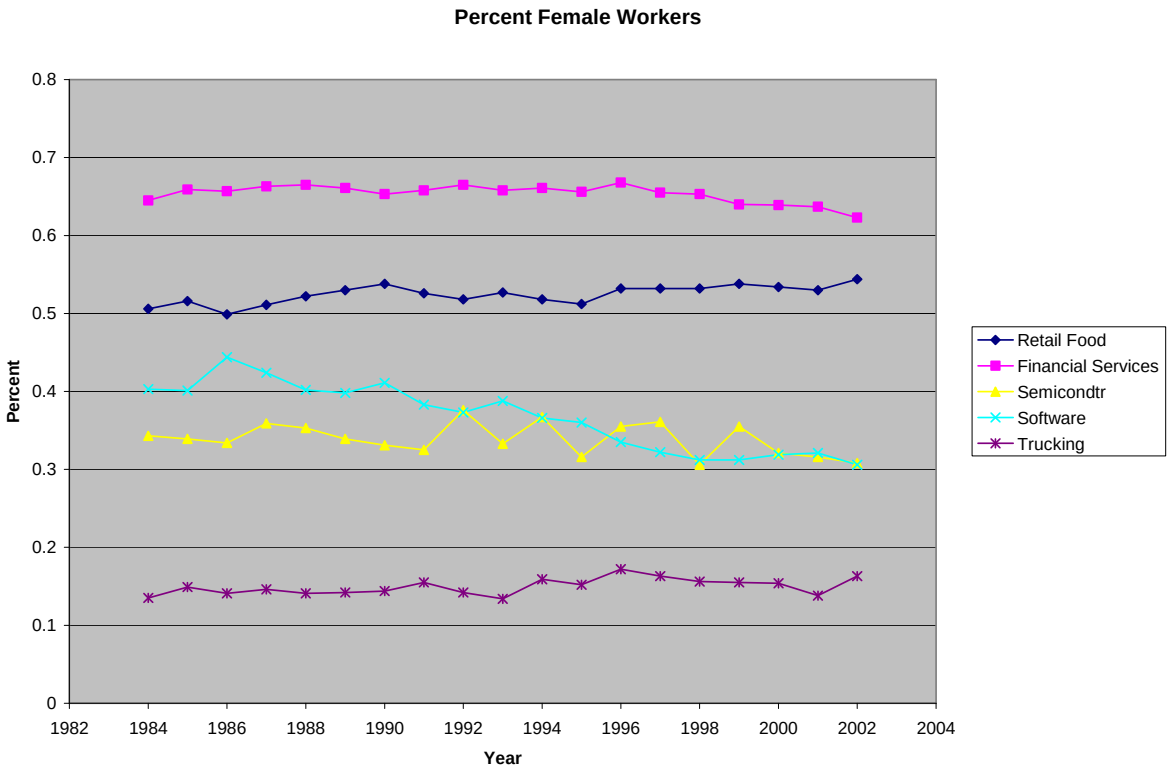

Percent Female Workers
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Percent
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year
Retail Food
Financial Services
Semicondtr
Software
Trucking

Figure 4

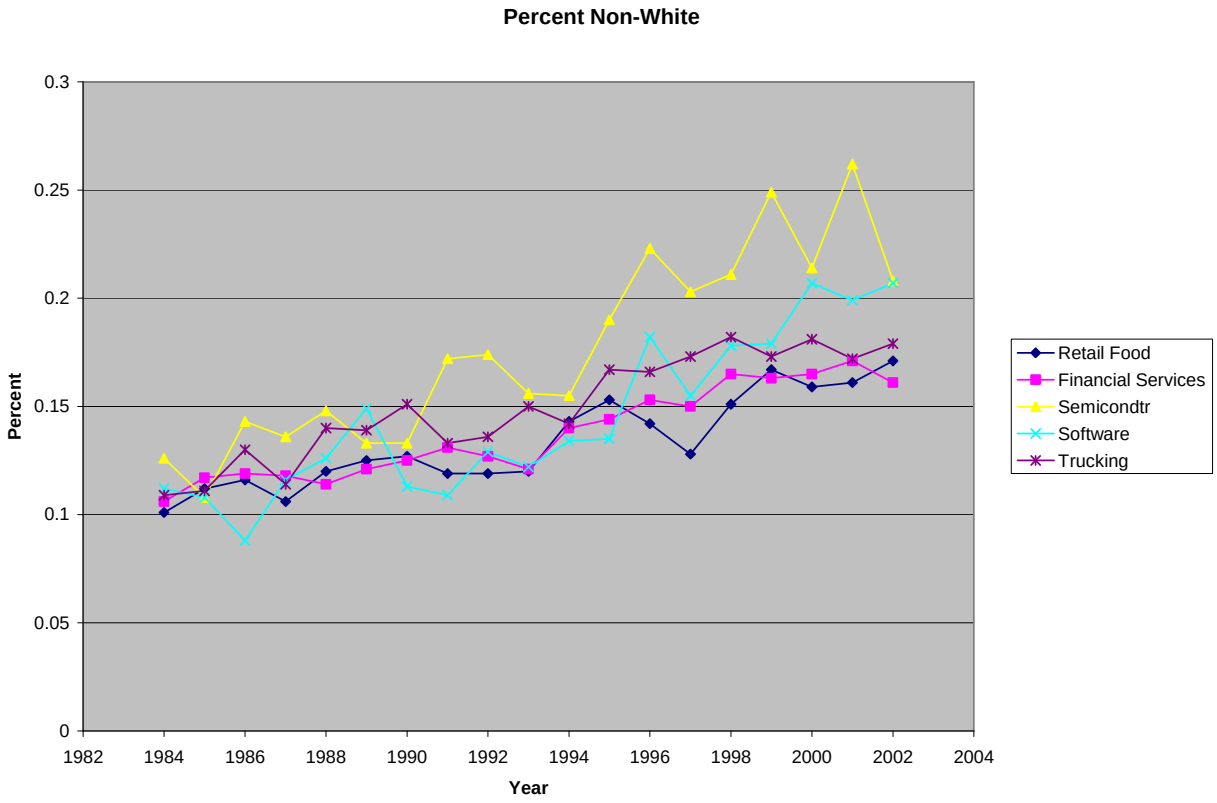

Percent Non-White
0.3
0.25
0.2
0.15
0.1
0.05
0
Percent
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year
Retail Food
Financial Services
Semicondtr
Software
Trucking

Figure 5

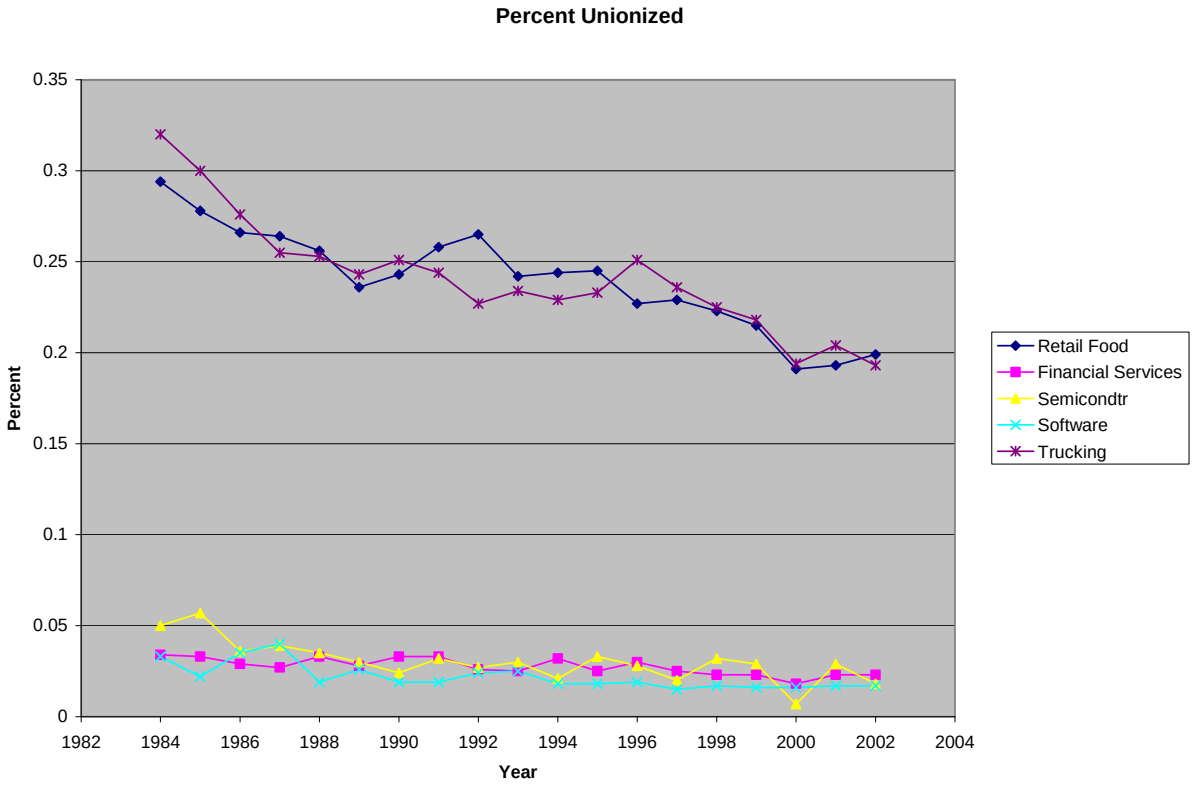

Percent Unionized
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Percent
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year
Retail Food
Financial Services
Semicondtr
Software
Trucking

Figure 7
Median earnings of high school graduates by industry

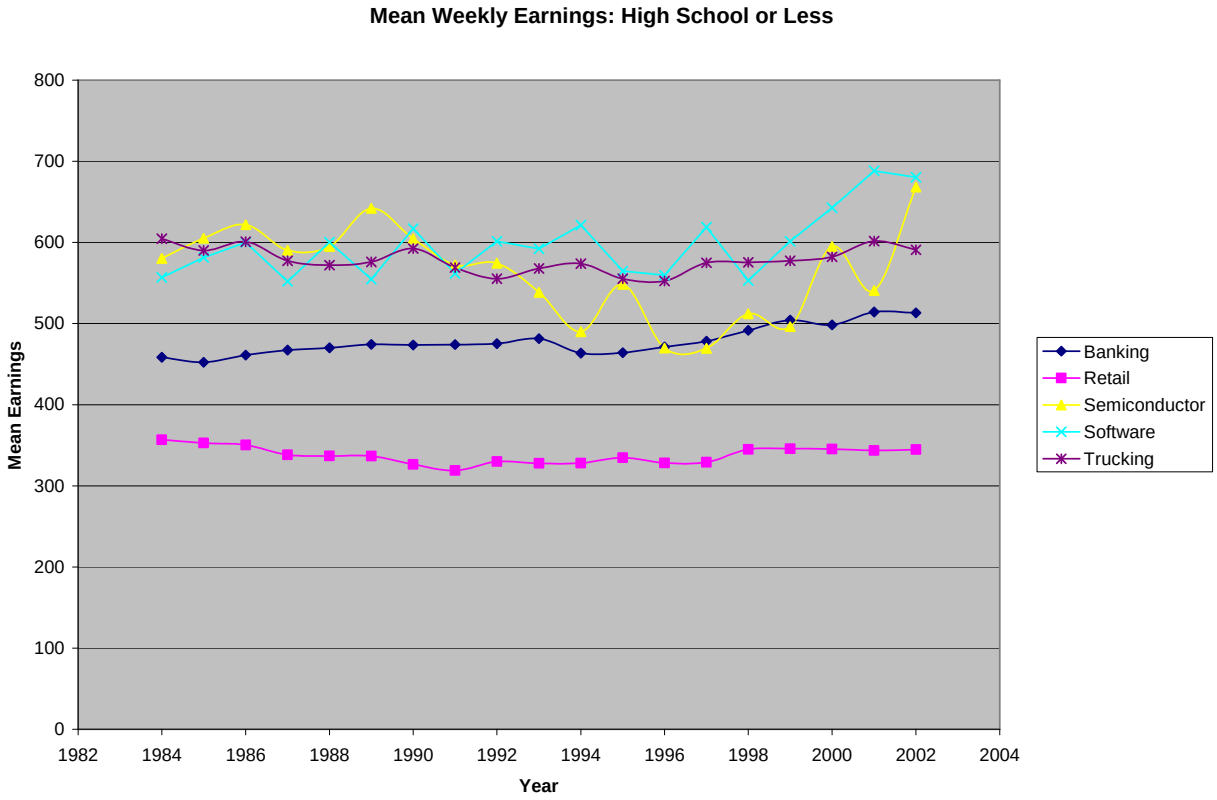


Figure 8
Median earnings of college graduates by industry

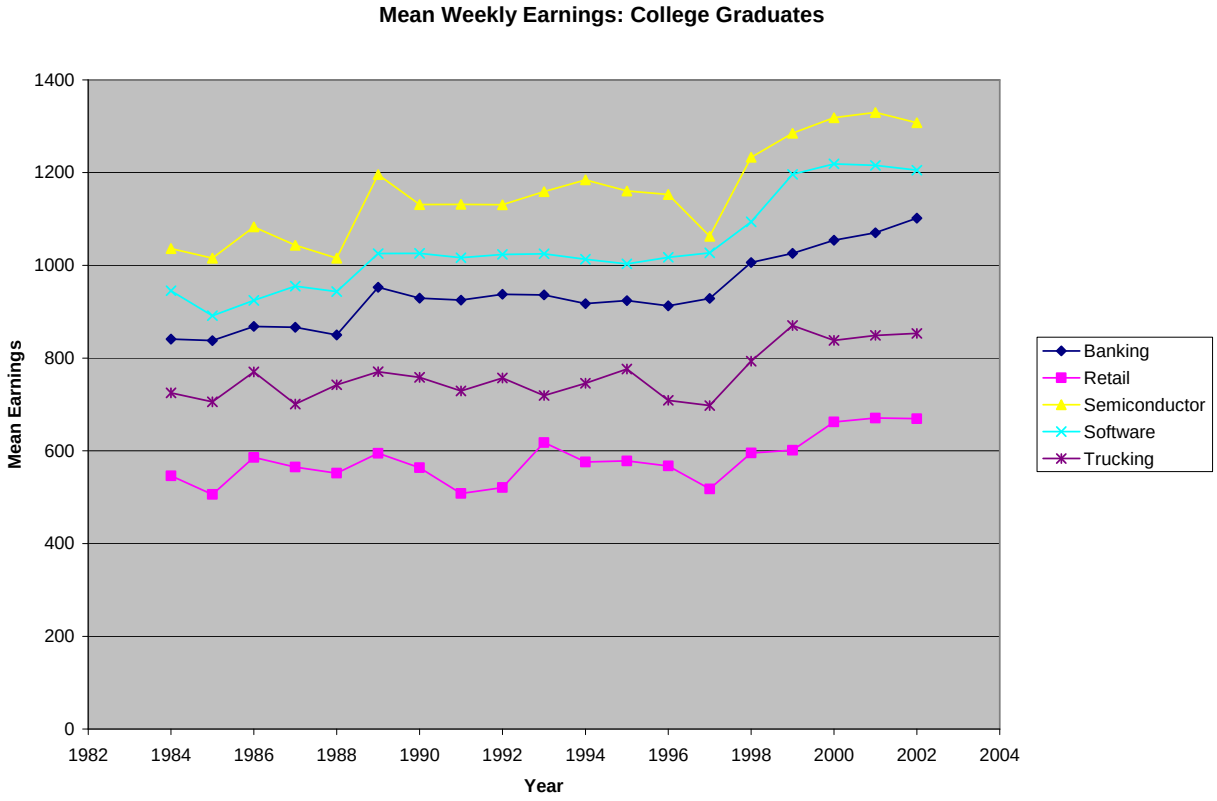


Figure 9

90th/10th Percentile Ratio

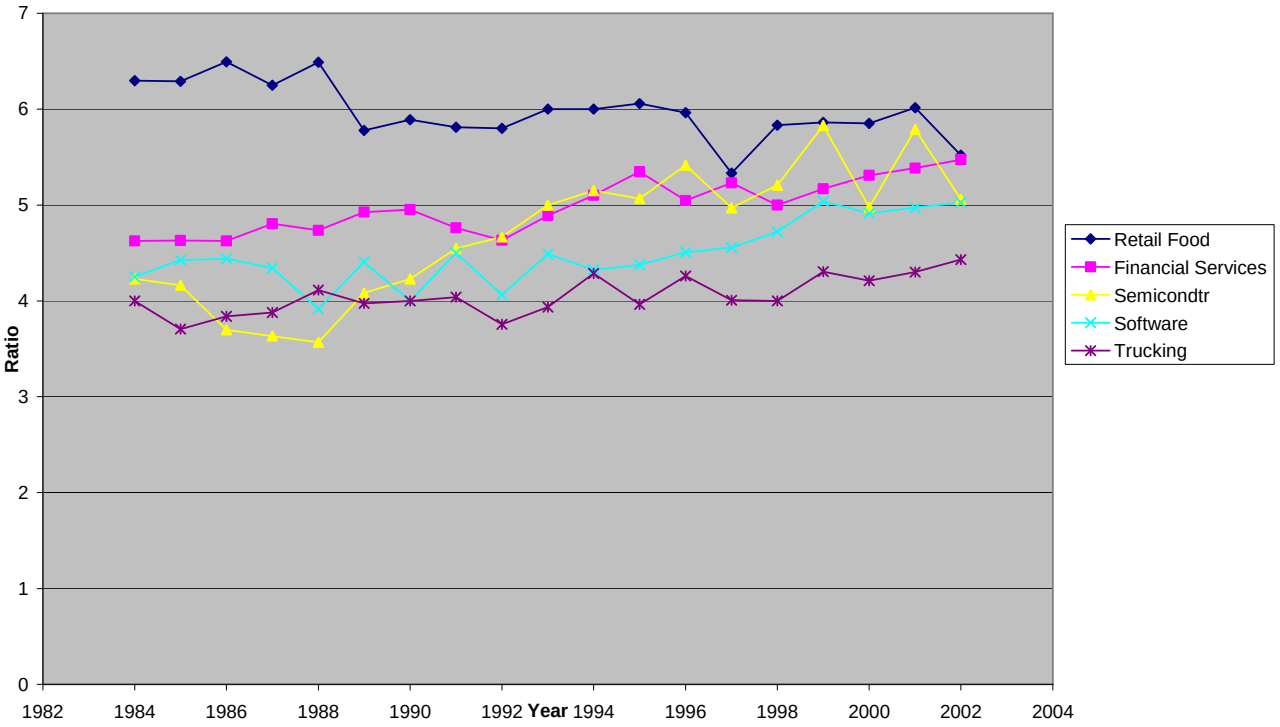
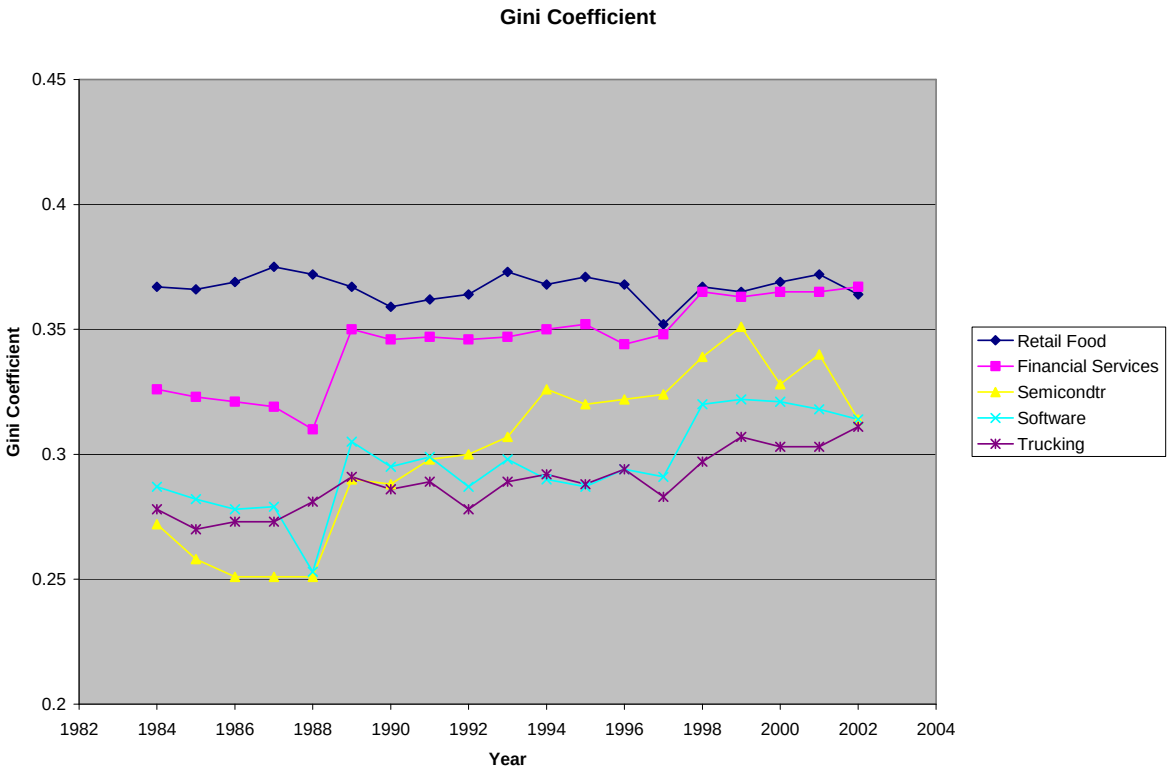


Figure 10


Gini Coefficient
0.45
0.4
0.35
0.3
0.25
0.2
Gini Coefficient
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year
Retail Food
Financial Services
Semicondtr
Software
Trucking

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