Earnings on the information technology roller coaster: insight from matched employer-employee data

Hotchkiss, Julie L. and Pitts, M. Melinda and Robertson, John

Federal Reserve Bank of Atlanta

October 2006

Published in Southern Economic Journal 73 (October 2006): 342–61.

Title:

"Earnings on the Information Technology Roller Coaster: Insight from Matched Employer-Employee Data"

Authors:

Julie L. Hotchkiss **(corresponding author)**
Federal Reserve Bank of Atlanta and Georgia State University
Research Department
Federal Reserve Bank of Atlanta
1000 Peachtree Street, NE
Atlanta, GA 30309-4470
Julie.L.Hotchkiss@atl.frb.org
(404) 498-8198

M. Melinda Pitts
Federal Reserve Bank of Atlanta
Research Department
Federal Reserve Bank of Atlanta
1000 Peachtree Street, NE
Atlanta, GA 30309-4470
Melinda.Pitts@atl.frb.org
(404) 498-7009

John C. Robertson
Federal Reserve Bank of Atlanta
Research Department
Federal Reserve Bank of Atlanta
1000 Peachtree Street, NE
Atlanta, GA 30309-4470
John.C.Robertson@atl.frb.org
(404) 498-8782

JEL Codes:
J31 - Wage Level and Structure, Wage Differentials by Skill, Training, Occupation, etc.
J62 - Job, Occupational, and Intergenerational Mobility

Acknowledgement Footnote:
The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Atlanta or the Federal Reserve System. The authors would like to thank Ethan Lewis, Kathryn Shaw, and Sabrina Pabilonia for their insightful suggestions, as well as participants at seminars presented at University of Colorado-Denver, University of North Carolina-Greensboro, and University of Kansas.

Abstract:

This paper uses matched employer-employee data for the state of Georgia to examine workers' earnings experience through the information technology (IT) sector's employment boom of the mid-1990s and bust in the early 2000s. The results show that even after controlling for pre-boom individual characteristics, transitioning out of the IT sector to a non-IT industry generally resulted in a large wage penalty. However, IT Service workers that transitioned to a non-IT industry still fared better than those who took a non-IT employment path. For IT Manufacturing workers, there is no benefit to having been touched by tech, likely because of the non-transferability of manufacturing experience to other industries.

"Earnings on the Information Technology Roller Coaster: Insight from Matched Employer-Employee Data"

1. Introduction

As roller coasters go, the information technology (IT) sector has provided quite a ride. The investment in and use of information technology was an important contributor to the rapid growth the U.S. economy experienced during the 1990s. Between 1996 and 2000, the IT-producing sector was responsible for an estimated 1.4 percentage points of the nation's average annual real GDP growth of 4.6 %, largely driven by business investment in IT products. Since 2000, however, the IT sector has been struggling. In particular, there was a sharp decline in business investment spending on IT during the 2001 recession, which then led to an analogous decline in the level of IT Manufacturing output. In 2002, it is estimated that IT-producing industries contributed only 0.1 percentage points to the economy's 2 % annual growth (Economics and Statistics Administration 2003).

As described in the next section, the IT boom of the 1990s led to a dramatic rise in employment in IT-producing industries, and the subsequent IT retrenchment resulted in a large decline in employment in the early 2000s. Such extraordinary movement in the labor market presents unique incentives and opportunities for workers. For instance, the IT boom may have led some workers to undertake human capital investments that may not easily be transferable to other industries. In addition, other workers may have experienced expanded opportunities that resulted from having worked in the IT sector during the boom. A goal of the analysis in this paper is to determine whether any general

labor market lessons can be learned from investigating the outcomes of workers in the IT sector during a period of volatile employment.

Because the IT-producing sector is concentrated in a few geographical locations such as California, Texas, Massachusetts, Washington, and Georgia, the IT boom and bust had a disproportionate impact on these locations (Daly and Valetta 2004). Using matched employer-employee data over the period 1993-2003, this paper focuses on two questions pertaining to the experience of workers in one of the IT centers, Georgia, during and after the IT boom: 1) How did the post-boom earnings of a worker vary by whether or not the worker transitioned out of the IT sector? and 2) How did the post-boom earnings of a worker who transitioned out of the IT sector compare to those of a worker who was not attached to the IT sector during the boom? These questions are addressed by comparing the predicted earnings across industry transition paths from a regression of post-boom earnings on boom, and post-boom employment activity, while controlling for pre-boom activity and earnings.[1]

2. Employment in the Information Technology Sector, 1993-2005

The U.S. Experience

The rapid adoption of information and communication technologies in the United States during the 1990s led to unprecedented demand for IT workers. As shown in Figure 1, from 1993 to 2000 the average number of workers in IT-producing industries in the U.S. increased by approximately 50 %, almost two and a half times as fast as employment in private sector non-IT industries. By the year 2000, investment spending on equipment and software reached an unprecedented 9.3 % of GDP (BEA 2005) and

there were 5.5 million workers at IT-producing establishments in the U.S., representing 5.0 % of total private sector employment.[2]

In 2001, investment spending on equipment and software began to decline, with spending as a share of GDP falling to 7.6 % by the year 2003 (BEA 2005). This drop in IT investment, along with the foreign outsourcing of IT work, contributed to a dramatic increase in layoffs in the IT sector and an ongoing weak job market for IT workers in the U.S. as a whole.[3] From 2000 to 2003, average employment in IT-producing industries declined by 21 %, compared to a 2.0 % decline for non-IT industries.

Although the rapid growth and decline in employment has not been uniform across all IT industries, the IT-producing sector, as a whole, had much more volatility in employment levels compared to related non-IT industries during this time period. As displayed in Table 1, average annual employment in IT Manufacturing (Computer Hardware and Communications Equipment) grew by 17.6 % between 1993 and 2000, much faster than the 2.3 % growth in non-IT Manufacturing. From 2000 to 2003 IT Manufacturing employment declined by 30.6 % from 2000 to 2003, while non-IT Manufacturing employment declined by 15.4 %. Employment at IT Service providers (establishments providing Software and Computer/Communications Services) increased by 68.0 % between 1993 and 2000, compared with a 22.0 % increase in non-IT Service industries. From 2000 to 2003, average employment in IT Services declined by 16.9 %, while non-IT Service employment grew by 0.5 %.

The Georgia Experience

The importance of the IT industry in Georgia is represented by the fact that the Atlanta, Georgia, MSA, which represents well over half of total employment in Georgia,

was one of the top ten Urban IT centers during the latter part of the 1990s, based on growth in the IT share of payrolls and share of US IT payrolls (Daly and Valetta 2004).

The IT employment trends for Georgia during this time period are roughly similar as that for the U.S., thus, it is expected that inferences based on analysis of Georgia's experience will be representative of the overall U.S. experience (see Figure 1 and Table 2). Between 1993 and 2000, average annual employment in Georgia's IT-producing sector increased by 65.3 %. Over the same period, non-IT employment increased by 28 %. By 2000, the IT-producing sector in Georgia represented 6.2 % of total private sector employment. From 2000 to 2003, Georgia experienced a 20 % decline in employment in IT-producing industries, whereas non-IT employment declined 3.1 %. At the IT sub-sector level, the trends between the U.S. and Georgia are also similar, although employment at providers of communication services grew somewhat more rapidly in Georgia than in the U.S. from 1993 to 2000, and also declined more rapidly from 2000 to 2003.

3. The Data and Sample Construction

The data used for the analysis come from two sets of state administrative records compiled by the Georgia Department of Labor for the purposes of administering the state's Unemployment Insurance (UI) program. The program provides an almost complete census of employees on non-farm payrolls, with information available on approximately 97 % of non-farm employees. The Individual Wage file contains information on a worker's total quarterly earnings from an employer.[4] Regrettably, the Individual Wage file contains no additional information about the worker's demographics

(e.g., education, gender, race, etc.) or about the worker's job (e.g., hours of work, weeks of work, or occupation). However, the worker's earnings can be tracked over time using a worker ID number and linked to an employer via a firm ID number.[5] These data are highly confidential and strictly limited in their distribution.

The Employer file contains records on all UI-covered firms and includes establishment level information on the number of employees and wage bill, as well as the NAICS classification of each establishment.[6] Because the Individual Wage file contains a firm rather than establishment identifier, a choice of which NAICS code to assign to each worker who was employed by a multi-establishment firm is required. Following the Department of Labor convention, a 6-digit NAICS code is assigned based on the largest share of the firm's total employment.

Time Period Definitions

The data are available from the first quarter of 1993 to the fourth quarter of 2003 (44 quarters). For the purposes of the analysis, it is necessary to split the sample into three time periods. Using the quarterly aggregate employment data it is determined that the peak of employment in the IT-producing sector occurred in the fourth quarter of 2000. This peak is used to define the end of the boom period. The post-boom period is from the first quarter of 2001 to the fourth quarter of 2003. The beginning of the boom period is less easily identified. The growth rate in IT employment in Georgia began to deviate from the growth in the non-IT sector during 1995. Thus, the boom period is defined as the period from the beginning of 1996 to 2000. Given that the data is available from the first quarter of 1993, the pre-boom period is then defined as all quarters from

1993 through 1995. These definitions also make the pre-boom and post-boom periods symmetric.

Industry Definitions

The data are restricted to private sector workers outside of the mining, natural resources, and agriculture sectors, due to the small share of total Georgia employment and the fact that less than half of agriculture workers are covered by UI. Government employees are excluded because they have been found to be quite distinct from private workers in their rates of pay, turnover, and sensitivity to economic conditions (McConnell, Brue, and MacPherson 2003). The effect of eliminating public employers from the sample is that employment in any quarter in which a typically private sector worker is employed by a government agency will be ignored and treated as non-employment. It was calculated that 87 % of all workers are employed only in the private or only in the public sectors over time, so the impact of this restriction should be minimal.

The IT-producing sector is divided into three components: the manufacturing of IT equipment or components, Software and Computer Services, and Communication Services.[7] The non-IT industries are Construction, non-IT Services (including Transportation and Utilities, Wholesale and Retail Trade, Finance, Insurance, and Real Estate, and Miscellaneous Non-IT Services), and non-IT Manufacturing. To assign a unique industry characteristic to each worker in the sample, the firm ID is assigned based on the employer from which the worker received his/her greatest earnings during that quarter.

Full-time Worker Restrictions

With no information on hours of work, number of weeks worked in a quarter, or timing of job changes, the sample is restricted to those who are most likely to be full-time workers who worked a complete quarter. This is accomplished by using only "interior" quarters of employment with real earnings of at least $3000 from one employer to identify employment activity. An interior quarter of earnings is sandwiched between two other quarters with real earnings of at least $3000 from the same employer.[8] Because the bulk of all quarters employed are quarters of interior earnings, not much earnings information is lost by focusing on interior quarters only. These restrictions minimize the probability that observed changes in earnings are the result of changes in hours or weeks of work rather than changes in productivity.

Worker Activity and Industry Classification

In each of the three periods, a worker can be involved in many activities: unemployed, out of the labor force, employed by one employer, or employed by multiple employers. The sample of interest consists of individuals whose primary activity during the boom is employment in Georgia. While any definition of "primary activity" over a long period of time is necessarily arbitrary, we choose to define a person's primary activity as the activity in which the person spends the largest share of his/her time over the period. This activity is referred to as a person's modal activity, and it basically has two possible designations: employment (observed with interior quarter wages) in Georgia, or not employed in Georgia (not observed with interior quarter wages). In order to have a complete earnings history on individual workers, the sample is restricted to individuals with employment as their modal activity in all of the three time periods.

The same strategy is used to identify the industry of employment during each period. The worker's modal industry is the one in which the worker spent most of his/her employed quarters. Analogously, a worker's modal wage during any of the periods is the average of the earnings received while employed in the worker's modal industry.[9] These concepts of modal activity and modal industry are used to collapse the 11 years of panel data into a single cross-section with an individual's earnings, primary activity, and characteristics identified for each time period.

Implication of Sample Restrictions

As a result of the restrictions on sample construction, the sample is not representative of all workers employed in Georgia over the time period studied, but rather represents the impact of the IT boom and bust on individuals with a strong attachment to the Georgia workforce throughout all periods. Because we have no information about individual human capital, hours of work, or occupations, these restrictions are designed to render the sample more homogeneous. Thus, we have greater confidence that the conclusions drawn about the characteristics that are observed (e.g., a worker's industry) are not confounded by unobservables. By definition, then, there should be less variation in outcomes across workers and across time than would be observed in the population. Any variation that is found across time periods or across industries, then, is likely an under-statement of what would be seen in the population as a whole.

Sample Means

The average real annualized earnings for workers in the sample by industry and time period are reported in Table 3. The reported average earnings are higher than the population as a whole because of the sample restriction requiring employment to be the

modal activity in all three periods; the sample is likely comprised of older, more experienced workers whose average earnings exceed the average of all workers. In general, workers in the IT-producing sector have higher wages than workers in non-IT industries in all three periods. IT Manufacturing is the lowest paying IT sector, but still considerably higher paying than non-IT Manufacturing. Computer and Software Service workers are the highest paid.

Sample means for the variables used in the regression analysis are in Appendix B, Column 1. On average, workers in this sample had 31 quarters of Georgia work experience and slightly more than one employer in any given quarter. Job mobility within each of the three time periods is measured by the total number of unique employers a worker had during a period, normalized by the number of quarters in the period. Workers averaged 0.08 employers during the boom period and slightly more (an average of 0.1 employers) during the pre-boom and post-boom periods.[10] This suggests that employment was slightly more stable during the boom period than during the post-boom period.

Dummy variables are included to indicate the worker's modal industry of employment during each of the three time periods. Over 60 % of the workers in the sample were employed in the non-IT Service sector in each of the periods. The next largest share of employment was in the reference industry, non-IT Manufacturing, although that share declined from 25 % in the pre-boom period to 22 % in the post-boom period. The share of Georgia's workforce in the IT sector was 6.5 % in the pre-boom period, 7.5 % in the boom period, and 7.4 % in the post-boom time period.

4. Individual Earnings Analysis

To analyze whether being a participant in an IT industry during the IT boom resulted in any post-boom earnings advantage, a worker's average modal earnings during the post-boom period are modeled as a function of pre-boom, boom, and post-boom employment activity, and pre-boom earnings:

$$LW_{i,t+1} = \beta_0 + \beta_1 X_i + \beta_2 LW_{i,t-1} + \mathrm{B}_1 I_{j,t-1} + \mathrm{B}_2 I_{j,t} + \mathrm{B}_3 I_{j,t+1} + \mathrm{B}_4 LW_{i,t-1} I_{j,t-1} + \mathrm{B}_5 LW_{i,t-1} I_{j,t} + \mathrm{B}_6 LW_{i,t-1} I_{j,t+1} + \varepsilon_{i,t+1}. \quad \textbf{(1)}$$

The dependent variable is the log of an individual's average quarterly earnings during the post-boom period while employed in his/her modal industry. X_i includes information on multiple job holdings (average number of employers per quarter during each period); total Georgia labor market experience during the period 1993-2003; and the number of employer changes during each time period, scaled by the length of the period. The I_j terms are binary indicators of the individual's modal industry of employment during the pre-boom ($t-1$), the boom (t), and the post-boom ($t+1$) periods. Including the modal industry of employment during each period allows for the simulation of different industry transition paths over the entire period. $\mathrm{B}_1, \mathrm{B}_2$, and B_3 are the vectors of coefficients for these modal industry indicators.

In order to control for individual fixed effects, the individual's pre-boom period log modal earnings, as well as other pre-boom employment characteristics such as the number of employers, multiple job holding, and modal industry, are included as explanatory variables. This added-value approach to controlling for individual fixed

effects has been applied in the education literature.[11] As expected, there is a strong correlation between pre-boom employment characteristics and post-boom earnings.[12]

To provide a more detailed accounting of the individual fixed effects, the pre-boom log wage is also interacted with the modal industry dummy variable ($LW_{i,t-1}I_j$) in each time period. This interaction allows the impact of a specific modal industry employment experience on post-boom earnings to vary by individual earnings experiences during the pre-boom period. This is important if, for example, high-earning individuals were more likely to follow a specific industry transition path. Not controlling for the potential industry choice dependence of earnings could lead to the conclusion that this particular transition led to higher post-boom earnings when, in fact, it was just higher earning workers who chose this path.

The regression results are presented in Appendix B, Column 2.[13] Consistent with human capital theory, workers are rewarded for having more labor market experience. The greater the number of quarters spent working, the more human capital is accumulated, and the higher the earnings. A higher rate of changing employers also has a positive effect on earnings in all three periods, with a smaller return in the post-boom period. This suggests that workers are able to chase higher wages by switching employers, especially during the boom and pre-boom periods. The smaller effect in the post-boom period likely reflects the greater degree to which employer changing was involuntary during this time period.

There is a post-boom benefit to having had more employers in a given quarter during the pre-boom period, suggesting that workers with more simultaneous employers

accumulated more transferable human capital skills. However, there is a penalty for having multiple employers in a given quarter during the boom and post-boom periods.

The estimated coefficients are used to simulate predicted annualized earnings for workers during the post-boom period based on their industry of employment during the boom and post-boom. These simulations, which are presented in Tables 4 and 5, are performed keeping all other characteristics of the worker, including pre-boom employment and wages, constant. To the extent that pre-boom employment characteristics have successfully controlled for individual heterogeneity, these predicted post-boom earnings will have been stripped of the human capital and individual selection influences on earnings comparisons, and yield the pure industry impact of a worker's employment path.

The first column of Table 4 indicates the industry transition path.[14] The second column gives the annualized predicted earnings based on the simulations with all variables held constant except the boom and post-boom industries. The third column compares the predicted post-boom earnings of a worker who transitioned out of a given industry to the predicted earnings of a worker who remained in that industry.

In general, workers who exited the IT sector during the post-boom period have lower predicted earnings than workers who remained. This lower wage, combined with the fact that layoffs were common in the IT sector post-boom (Economics and Statistics Administration 2003), suggests that, on average, the separation from the IT sector was involuntary. The largest predicted relative wage decline is for workers in IT Service industries who moved to a non-IT Service industry; the predicted earnings for these workers are between 23 and 26 % lower than workers who did not leave IT Services.

Because the sample is restricted to workers who were mostly employed during the post-boom time period, excluding workers who left the IT sector into mostly non-employment in Georgia means that the size of the penalty from exiting IT is likely underestimated. However, the percent of time workers spent in the post-boom period with no earnings is relatively small. Of all workers whose modal employment was in the IT sector during the boom, an average of 17.5 % of the post-boom period was spent in non-employment. This is the same average amount of time spent in non-employment by those in non-IT Service industries during the boom. In contrast, workers in non-IT Manufacturing and in Construction during the boom spent an average 22 and 27 %, respectively, of their post-boom period in non-employment.

Post-boom movements across industries within the IT-producing sector are generally associated with a predicted wage benefit. For instance, both IT Manufacturing and Software and Computer Services workers that transitioned into the IT Communication Services industry post-boom are predicted to earn more, on average, than workers that remained in their respective industry.

In all cases, transitioning into an IT-producing industry from a non-IT industry also resulted in predicted relative wage gain.[15] This premium from transitioning into the IT sector during a period of declining employment supports the findings of Hotchkiss. Pitts, and Robertson (2004), who found that workers who are hired by a firm while the firm is downsizing, experience a significant earnings boost.

The largest gains for transitioning came from entering the IT Communication Services industry, with premiums ranging from 19 to 35 %. However, workers leaving IT Communications Services also experienced substantial wage penalties from any

transition. Together, these results may suggest the presence of some other wage premium accruing to workers in the Communication Services industry, in addition to any wage effects associated with transferability of human capital.

IT Manufacturing workers that moved to a non-IT Manufacturing job post-boom have predicted earnings that are on par with those of other manufacturing workers, and those moving into non-IT Service or Construction industries earned less than those with no IT Manufacturing experience. A similar result holds for non-IT Manufacturing workers, suggesting that the predicted wage losses are partly attributable to the lack of transferability of manufacturing specific skills outside of manufacturing.

The results in Table 4 demonstrate the costs and benefits associated with a given industry transition relative to the boom-period industry of employment. Table 5 compares the predicted earnings of a worker from the perspective of the post-boom industry of employment. Having controlled for pre-boom individual characteristics, these results provide evidence of the costs or benefits associated with having worked in an IT-producing industry during the boom relative to having taken a non-IT employment path. The predicted earnings suggest that although boom-IT workers that transitioned to non-IT employment post-boom earned less than the boom-IT workers that did not transition, the earnings level is higher than if they had not been employed in the IT sector during the boom. In general, there is a post-boom benefit to having been employed in the IT sector in the boom period. For example, a boom-period IT Software and Computer Service worker that worked in non-IT Manufacturing during the post-boom period is predicted to have earned approximately 20 % more than non-IT Manufacturing workers with no IT-experience. This likely reflects the fact that the computer and software skills obtained

during the IT boom period were transferable to the non-IT Manufacturing sector (such as designing and programming automated systems, maintaining networks, etc).

5. Summary and Potential Implications

There was a significant employment and wage boom in the IT-producing sector during the 1990s. Employment grew rapidly during the period from 1996 to 2000, and the workers in the IT-producing sector were paid a substantial wage premium over workers in non-IT industries during this time. However, following this boom period of growth there was a dramatic employment decline in the IT sector. This paper compares the impact of these industry changes on the post-boom earnings experience of workers employed in the IT-producing sector during the boom with the earnings experience of workers employed in other industries during the same time period. This analysis utilizes matched employer-employee data from the Georgia Department of Labor on workers whose modal activity was employment over the period 1993 to 2003.

After controlling for individual characteristics prior to the IT boom, it is shown that workers who were able to maintain their attachment to the IT sector after the boom ended in 2000, could expect to maintain this wage premium, whereas those that transitioned out of the IT sector in the post-boom period expected relatively lower wages. This suggests that if an industry is not able to sustain a period of unusually accelerated employment growth, then workers from that industry are likely to suffer an earnings loss when this growth subsides.

The results also show that while leaving the IT-producing sector lowered post-boom expected wages, workers transitioning from the IT Service sector were still

predicted to fare better than those who did not have any IT attachment during the boom. In other words, post-boom earnings were predicted to be lower among workers who left the IT sector to work in a non-IT industry, relative to those who stayed in IT. However, most of the workers who left IT fared better than if they had been employed in a non-IT industry during the boom. This suggests that workers who take a potentially risky chance on joining a fast-growing sector do not necessarily get burned in the end.

Lastly, this advantage of transitioning from a fast-growing sector after its boom appears to be more related to the transferability of skills to other sectors rather than mere identification with the booming sector. This is evidenced by the lower predicted post-boom earnings for workers employed in IT Manufacturing during the boom, but employed elsewhere post-boom. This is likely due to the non-transferability of manufacturing experience. In contrast, boom-IT Service workers, who likely possessed more easily transferable skills, were predicted to enjoy a significant post-boom earnings advantage over boom non-IT workers, even when transferring to non-IT industries.

References

BEA. 2005. Bureau of Economic Analysis National Economic Accounts, All NIPA Tables, Table 1.15. http://bea.gov/bea/dn/nipaweb/selecttable.asp?selected=N#S1. Accessed 27 March 2006.

BLS. 2001. Bureau of Labor Statistics 2001 Extended Mass Layoffs. http://www.bls.gov/schedule/archives/mslo_nr.htm#2001. Accessed 27 March 2006.

BLS. 2006. Bureau of Labor Statistics, Quarterly Census of Employment and Wages. http://data.bls.gov/cgi-bin/dsrv?en. Accessed 30 March 2006.

Bowles, Robert. 2004. Employment and Wage Outcomes for North Carolina's High-Tech Workers. *Monthly Labor Review* 127: 31-9.

Daly, Mary C., and Robert G. Valletta. 2004. Performance of Urban Information Technology Centers: The Boom, the Bust, and the Future. *Federal Reserve Bank of San Francisco Economic Review*: 1-18.

Dardia, Michael, Tracey Grose, Hugh Roghmann, and Peggy O'Brien-Strein. 2005. *The High-Tech Downturn in Silicon Valley: What Happened to All Those Skilled Workers?* Burlingame, CA: The Sphere Institute.

Economics and Statistics Administration. 2003. *Digital Economy 2003*. Washington, DC: U.S. Department of Commerce.

Haltiwanger, John, Julie Lane, James Spletzer, Jules Theeuwes, and Kenneth Troske. 1999. *The Creation and analysis of Employer-Employee Matched Data*. Amsterdam: North Holland.

Hotchkiss, Julie L., M. Melinda Pitts, and John C. Robertson. 2004. "Wage Gains Among Job Changers Across the Business Cycle: Insight from State Administrative Date." *Federal Reserve Bank of Atlanta Working Paper No. 2004-19*.

McConnell, Campbell R., Stanley L. Bruce, and David MacPherson. 2003. *Contemporary Labor Economics*, 6th ed. Columbus, OH: McGraw-Hill/Irwin.

Todd, Petra E., and Kenneth I. Wolpin. 2003. On the Specification and Estimation of the Production Function for Cognitive Achievement. *The Economic Journal* 113: F3-33.

White, Sammis B., John F. Zipp, William F. McMahon, Peter D. Reynolds, Jeffrey D. Osterman, and Lisa S. Binkley. 1990. ES202: The Data Base for Local Employment Analysis. *Economic Development Quarterly* 4: 240-53.

Zoghi, Cindy, and Sabrina Wulff Pabilonia. 2004. Which Workers Gain from Computer Use? Working Paper No. 373, Bureau of Labor Statistics.

Endnotes

[1] Matched employer-employee data have also been used to depict trends in employment and earnings in the IT sector in California (Dardia et al. 2005) and North Carolina (Bowles 2004). However, these analyses are purely descriptive in nature, in that they do not attempt to control for industry selection.

[2] Bureau of Labor Statistics, Quarterly Census of Employment and Wages (www.bls.gov/cew). These data are described in more detail below. Appendix A contains the definition of IT-producing industries used in this study and the relative size of each industry.

[3] According to the BLS Mass Layoff Statistics (BLS 2001), the number of mass layoff events in the IT sector more than tripled between 2000 and 2001, relative to a 36 % growth for all industries. (accessed May 18, 2005).

[4] Included in earnings are pay for vacation and other paid leave, bonuses, stock options, tips, the cash value of meals and lodging, and in some states, contributions to deferred compensation plans (such as 401(k) plans). Covered employer contributions for old-age, survivors, and disability insurance (OASDI), health insurance, unemployment insurance, workers' compensation, and private pension and welfare funds are not reported as wages. Employee contributions for the same purposes, however, and other money withheld for income taxes, union dues, and so forth, are reported even though they are deducted from the worker's gross pay.

[5] See Haltiwanger et al. (1999) for a collection of studies using these and other employer-employee matched data sets.

[6] White et al. (1990) provide an extensive discussion about the use of these employment data, commonly referred to as the Quarterly Census of Employment and Wages (QCEW), or ES-202 data.

[7] The classifications are based on those used in the Department of Commerce Report: *Digital Economy 2003*, with two modifications: Computer Training Schools are added to the Software and Computer Services category, and Computer Software Wholesalers and Retailers are included in Software and Computer Services instead of Computer Hardware.

[8] This cut-off value was used in a study of Californian IT employment (Dardia et al. 2005). Among workers with *any* earnings in a quarter, anywhere between 25 and 32 %, fall below the $3,000 real earnings cut-off. However, only approximately 13 % of workers with interior earnings fall below this line. This roughly coincides with the percent of workers that were part-time employed in the U.S. in 2004. Any worker whose nominal earnings were top-coded at $100,000 per quarter by the Department of Labor was eliminated from the sample. 99 % of workers had quarterly earnings less than $26,000 in 1993 and less than $60,000 in 2004.

[9] Workers may have had employment in some other sector during the quarter, but not as much as in that sector identified as their modal employment, and the wages in their non-modal employment are not used in the calculation of modal wage.

[10] This characteristic is calculated by dividing the total number of unique employers by the total number of quarters during the period. Since the boom period is longer than the post- and pre-boom periods, the total number of different (unique) employers is normalized by the period length to make the characteristic comparable across periods.

For example, if a worker has one employer over time, his/her average number of employers will be 0.05 (1 employer/20 quarters) during the boom and 0.08 (1 employer/12 quarters) during the pre-boom and post-boom periods.

[11] See Todd and Wolpin (2003). Zoghi and Pabilonia. (2004) provide a labor market application of the added-value methodology.

[12] The estimation results absent the pre-boom controls are available from the authors upon request. The results are qualitatively similar to those presented here, but suggest a much larger positive impact of having been employed in the technology sector during the boom than when the pre-boom controls are included.

[13] A fixed-effects panel data model was also estimated using individual quarterly data. That specification, however, did not add any insights over the simpler three-period specification.

[14] In the data, a worker may be observed changing industries if he/she changes from an employer in one industry to an employer in a different industry, or if the employer's industry classification changes. Because of the more narrow industry classification of IT firms, this second type of transition occurs slightly more frequently to workers in the IT industries (roughly 2 % of IT firms versus 0.4 % of non-IT firms). Technically, both types of transitions are industry transitions, although the second type does involve an employer change. As a result, the measured wage effect from any industry transition is likely dampened. This is because changing employers is typically associated with greater wage gains (e.g., see Hotchkiss, Pitts, and Robertson. 2004).

[15] Given the declining employment levels in the IT sector, the number of intra-IT employer changes and transitions into the IT-producing sector is not large in the sample – see Appendix C.

Table 1. U.S. Private Sector Employment Trends

	Employment ('000) Annual Average			% Change	
Sector	**1993**	**2000**	**2003**	**93-00**	**00-03**
IT-Producing Sector	3,646 (3.9)	5,482 (5.0)	4,349 (4.1)	50.4	-20.7
Software & Computer Services	1,434 (1.5)	2,729 (2.5)	2,235 (2.1)	90.3	-18.1
Communications Services	934 (1.0)	1,250 (1.1)	1,071 (1.0)	33.8	-14.3
IT Manufacturing (Computer Hardware and Communications Equipment)	1,278 (1.4)	1,503 (1.4)	1,043 (1.0)	17.6	-30.6
Non-IT Manufacturing	15,495 (16.9)	15,845 (14.3)	13,412 (12.5)	2.3	-15.4
Non-IT Service	64,969 (70.9)	79,261 (71.6)	79,649 (74.1)	22.0	0.5
Construction	4,693 (5.1)	6,709 (6.1)	6,694 (6.2)	43.0	-0.2

Note: Numbers in parentheses are shares of total private sector employment. Data on natural resources and mining, along with agriculture are excluded from the Table.

Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (www.bls.gov/cew), (BLS 2006).

Table 2. Georgia Private Sector Employment Trends

	Employment ('000) (Share of Total Employment)			% Change	
Sector	**1993**	**2000**	**2003**	**93-00**	**00-03**
IT-producing Sector	123.41 (4.8)	203.93 (6.2)	163.51 (5.1)	65.3	-19.8
Software & Computer Services	61.53 (2.4)	117.96 (3.6)	98.81 (3.1)	91.7	-16.2
Communications Services	46.57 (1.8)	66.63 (2.0)	51.43 (1.6)	43.1	-28.4
IT Manufacturing (Computer Hardware and Communications Equipment)	15.31 (0.6)	19.34 (0.6)	13.27 (0.4)	26.4	-31.4
Non-IT Manufacturing	502.19 (19.7)	514.77 (15.6)	437.50 (13.8)	2.5	-15.0
Non-IT Private Service	1,758.40 (69.0)	2,342.21 (70.9)	2,335.65 (73.72)	33.2	-0.3
Construction	133.94 (5.3)	208.48 (6.3)	197.63 (6.2)	55.7	-5.2

Note: Numbers in parentheses are shares of total private sector employment. Data on natural resources and mining, along with agriculture are excluded from the Table.

Source: Authors' calculations based on Georgia administrative data files.

Table 3. Annualized Average Modal Earnings by Sector and Time Period

	Pre-boom	Boom	Post-boom
IT Software and Computer Services	$53,674 ($31,108) [34,972]	$67,927 ($37,076) [43,987]	$77,036 ($41,715) [44,891]
IT Communication Services	$52801 ($21,252) [33,757]	$61,016 ($26,739) [37,196]	$63,257 ($29,924) [36,611]
IT Manufacturing	$42,448 ($26,394) [12,551]	$46,886 ($28,888) [12,980]	$54,034 ($35,400) [10,422]
Non-IT Service	$34,814 ($25,527) [782,091]	$40,886 ($28,745) [766,201]	$44,398 ($32,981) [796,826]
Construction	$33,486 ($19,232) [71,760]	$39,520 ($21,557) [79,693]	$42,115 ($24,539) [85,478]
Non-IT Manufacturing	$33,013 ($19,522) [316,078]	$37,805 ($21,668) [311,152]	$40,162 ($24,681) [276,981]

Note: Dollar values are deflated using the PCE chain-type deflator (normalized to 2003 dollars). Standard deviation is in parentheses and number of observation is in brackets.

Table 4. Simulated Post-boom Earnings by Boom Industry

(1)	(2)	(3)
Industry Transition	Annualized predicted earnings Post-Boom	% gain (loss) from transitioning
Non-IT Service Boom		
Post-Boom Industry		
Non-IT Service	$39,302	
Construction	$40,100	2.03%
Non-IT Manufacturing	$42,843	9.01%
IT Manufacturing	$44,549	13.35%
IT Software and Computer Services	$51,100	30.02%
IT Communication Services	$53,107	35.13%
Construction Boom		
Post-Boom Industry		
Construction	$40,607	
Non-IT Service	$39,799	-1.99%
Non-IT Manufacturing	$43,385	6.84%
IT Manufacturing	$45,113	11.10%
IT Software and Computer Services	$51,747	27.43%
IT Communication Services	$53,780	32.44%
Non-IT Manufacturing Boom		

Post-Boom Industry		
Non-IT Manufacturing	$40,597	
Non-IT Service	$37,242	-8.26%
Construction	$37,998	-6.40%
IT Manufacturing	$42,214	3.98%
IT Software and Computer Services	$48,422	19.27%
IT Communication Services	$50,324	23.96%
IT Manufacturing Boom		
Post-Boom Industry		
IT Manufacturing	$43,008	
Non-IT Service	$37,942	-11.78%
Construction	$38,712	-9.99%
Non-IT Manufacturing	$41,360	-3.83%
IT Software and Computer Services	$49,332	14.70%
IT Communication Services	$51,270	19.21%

IT Software and Computer Services Boom		
Post-Boom Industry		
IT Software and Computer Services	$58,370	
Non-IT Service	$44,893	-23.09%
Construction	$45,804	-21.53%
Non-IT Manufacturing	$48,937	-16.16%
IT Manufacturing	$50,886	-12.82%
IT Communication Services	$60,662	3.93%
IT Communication Services Boom		
Post-Boom Industry		
IT Communication Services	$57,197	
Non-IT Service	$42,328	-26.00%
Construction	$43,187	-24.49%
Non-IT Manufacturing	$46,142	-19.33%
IT Manufacturing	$47,979	-16.12%
IT Software and Computer Services	$55,035	-3.78%

Notes: Complete parameter estimates generating these earnings predictions are found in Appendix B. The number of workers in the sample that followed these transition paths is in Appendix C.

Table 5. Simulated Post-boom Earnings by Post-Boom Industry

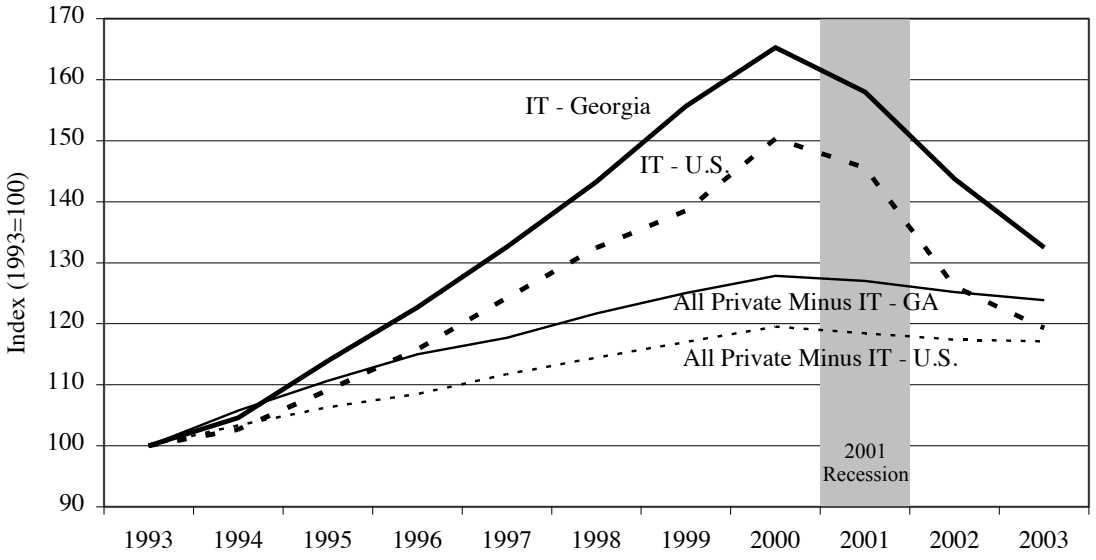
(1)	(2)	(3)
Industry Transition	Annualized predicted earnings Post-Boom	% gain (loss) from transitioning
Non-IT Service Post-Boom		
Boom Industry		
Non-IT Service	$39,302	
Construction	$39,799	1.26%
Non-IT Manufacturing	$37,242	-5.24%
IT Manufacturing	$37,942	-3.46%
IT Software and Computer Services	$44,893	14.23%
IT Communication Services	$42,328	7.70%
Construction Post-Boom		
Boom Industry		
Construction	$40,607	
Non-IT Service	$40,100	-1.25%
Non-IT Manufacturing	$37,998	-6.43%
IT Manufacturing	$38,712	-4.67%
IT Software and Computer Services	$45,804	12.80%
IT Communication Services	$43,187	6.35%
Non-IT Manufacturing Post-Boom		

Boom Industry		
Non-IT Manufacturing	$40,597	
Non-IT Service	$42,843	5.53%
Construction	$43,385	6.87%
IT Manufacturing	$41,360	1.88%
IT Software and Computer Services	$48,937	20.54%
IT Communication Services	$46,142	13.66%
IT Manufacturing Post-Boom		
Boom Industry		
IT Manufacturing	$43,008	
Non-IT Service	$44,549	3.58%
Construction	$45,113	4.89%
Non-IT Manufacturing	$42,214	-1.85%
IT Software and Computer Services	$50,886	18.32%
IT Communication Services	$47,979	11.56%

IT Software and Computer Services Post-Boom		
Boom Industry		
IT Software and Computer Services	$58,370	
Non-IT Service	$51,100	-12.46%
Construction	$51,747	-11.35%
Non-IT Manufacturing	$48,422	-17.04%
IT Manufacturing	$49,332	-15.48%
IT Communication Services	$55,035	-5.71%
IT Communication Services Post-Boom		
Boom Industry		
IT Communication Services	$57,197	
Non-IT Service	$53,107	-7.15%
Construction	$53,780	-5.97%
Non-IT Manufacturing	$50,324	-12.02%
IT Manufacturing	$51,270	-15.48%
IT Software and Computer Services	$60,662	6.06%

Notes: Complete parameter estimates generating these earnings predictions are found in Appendix B. The number of workers in the sample that followed these transition paths is in Appendix C.

Figure 1. Georgia and U.S. Employment Indices: IT and All Private Minus IT (1993=100, NSA).



Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (www.bls.gov/cew).

Appendix A: IT-Producing NAICS Definitions and Distribution of Average 2000 Technology Employment in U.S. and Georgia

NAICS Industry Definition	NAICS	U.S.	Georgia
IT Manufacturing			
Computer Hardware			
Electronic computers	334111	13.4	17.1
Computer storage devices	334112	3.2	3.3
Computer terminals	334113	2.1	3
Other computer peripheral equipment	344119	5.9	11.1
Electron tubes	334411	1.7	0
Bare printed circuit boards	334412	11.8	25.6
Semiconductors and related devices	334413	24.6	3
Electronic capacitors	334414	1.4	2.8
Miscellaneous electronic components	334415,6,9	10.5	6.4
Electronic connectors	334417	2.1	1.6
Printed circuit assemblies	334418	5.6	9.9
Industrial process variable instruments	334513	5.9	17.5
Electricity and signal testing instruments	334515	5.6	0.2
Analytical laboratory instruments	334516	2.8	0.1
Semiconductor machinery	333295	1.9	0.3
Office machinery	333313	1.3	1.5
		100	**100**

Communications Equipment			
Telephone apparatus	334210	32.6	13.4
Broadcast and wireless communications equipment	334220	34.0	36.2
Audio and video equipment	334310	16.2	12.3
Fiber optic cable manufacturing	334611	8.4	15.4
Software reproducing	334613	2.7	9.8
Magnetic and optical recording media	335921	6.1	13
		100	**100**
IT Software and Computer Services			
Software publishers	511210	9.8	11.5
ISPs and web search portals	518111,2	7.0	7.3
Data processing and related services	518210	12	11.1
Computer and software wholesalers	423430	11	19.4
Computer and software retailers	443120	8.1	4.1
Custom computer programming services	541511	21.1	17.5
Computer systems design services	541512	19.5	13.3
Computer facilities management services	541513	2.4	7.8
Other computer-related services	541519	5.5	4.7
Office machine rentals and leasing	532420	0.5	0.8
Computer and office machine repair	811212	1.8	1.7
Computer Training Schools	611420	1.1	0.9
		100	**100**

IT Communication Services			
Wired telecommunications carriers	517110	57.5	66.8
Cellular and other wireless carriers	517212	12.3	11.4
Telecommunications resellers	517310	16.1	14.4
Cable and other program distribution	517510	10.0	6.3
Satellite and other telecommunications services	517410,910	2.5	0.5
Communications equipment repair and leasing	811213	1.6	0.6
		100	**100**

Note: The classifications are based on those used in the Department of Commerce Report: *Digital Economy 2003*, with two modifications: Computer Training Schools are added to the Software and Computer Services category, and Computer Software Wholesalers and Retailers are included in Software and Computer Services instead of Computer Hardware. Source for employment shares: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (www.bls.gov/cew), and authors' calculations based on Georgia administrative data files.

Appendix B: Sample Means and

OLS Log Wage Regression: Post-Boom Time Period

	Mean (std. dev.)	**Coefficient (std. error)**
Log Quarterly Earnings (dependent variable)	9.1497 (0.5772)	
Pre-boom Period Modal Employment Industry		
IT Manufacturing	0.0100 (0.0997)	-1.525 (0.0787)
IT Software and Computer Services	0.0280 (0.1648)	0.1638 (0.0485)
IT Communication Services	0.0270 (0.162)	-1.0473 (0.0683)
Non-IT Service	0.6251 (0.4841)	0.3498 (0.0227)
Construction	0.0574 (0.2325)	-0.1570 (0.046)
Boom Log Earnings Interacted with Pre-boom Industry		
Pre-boom Log Earnings * IT Manufacturing	0.0916 (0.911)	0.1791 (0.0087)
Pre-boom Log Earnings * IT Software and Computer Srvcs	0.2616 (1.5452)	-0.00002 (0.0053)
Pre-boom Log Earnings * IT Communication Services	0.2539	0.1093

	(1.5263)	(0.0075)
Pre-boom Log Earnings * Non-IT Service	5.5603	-0.0229
	(4.3289)	(0.0026)
Pre-boom Log Earnings * Construction	0.5113	0.0345
	(2.076)	(0.0052)
Boom Period Modal Employment Industry		
IT Manufacturing	0.0104	0.5122
	(0.1013)	(0.0914)
IT Software and Computer Services	0.0352	1.2436
	(0.1841)	(0.051)
IT Communication Services	0.0297	1.2020
	(0.1698)	(0.0688)
Non-IT Service	0.6124	-0.0209
	(0.4872)	(0.0282)
Construction	0.0637	0.4027
	(0.2442)	(0.0537)
Boom Log Earnings Interacted with Boom Industry		
Pre-boom Log Earnings * IT Manufacturing	0.0937	-0.0553
	(0.9165)	(0.0102)
Pre-boom Log Earnings * IT Software and Computer Srvcs	0.3261	-0.1184
	(1.7117)	(0.0057)
Pre-boom Log Earnings * IT Communication Services	0.2764	-0.1203
	(1.5811)	(0.0076)

Pre-boom Log Earnings * Non-IT Service	5.4506	0.0084
	(4.3583)	(0.0032)
Pre-boom Log Earnings * Construction	0.5667	-0.0377
	(2.1759)	(0.0061)
Post-boom Period Modal Employment Industry		
IT Manufacturing	0.0083	-0.07627
	(0.0909)	(0.0866)
IT Software and Computer Services	0.0359	1.1817
	(0.186)	(0.0457)
IT Communication Services	0.0293	1.4508
	(0.1685)	(0.0565)
Non-IT Service	0.6368	0.3752
	(0.4809)	(0.0251)
Construction	0.0683	1.7304
	(0.2522)	(0.0452)
Boom Log Earnings Interacted with Post-boom Industry		
Pre-boom Log Earnings * IT Manufacturing	0.0754	0.0129
	(0.8245)	(0.0096)
Pre-boom Log Earnings * IT Software and Computer Srvcs	0.3327	-0.1126
	(1.7278)	(0.005)
Pre-boom Log Earnings * IT Communication Services	0.2696	-0.1385
	(1.5554)	(0.0062)
Pre-boom Log Earnings * Non-IT Service	5.6685	-0.0517

	(4.303)	(0.0028)
Pre-boom Log Earnings * Construction	0.6078 (2.2478)	-0.2013 (0.0051)
Log Pre-Boom Earnings	8.9255 (0.5406)	0.7867 (0.0016)
Average Number of employers in a given quarter during the pre-boom period	1.0650 (0.2091)	0.0670 (0.0018)
Average Number of employers in a given quarter during the boom period	1.0630 (0.1843)	-0.01431 (0.0023)
Average Number of employers in a given quarter during the post-boom period	1.0529 (0.1971)	-0.0996 (0.002)
Total Number of employers during the pre-boom period (normalized by # of quarters)	0.10122 (0.0374)	0.6225 (0.0094)
Total Number of employers during the boom period (normalized by # of quarters))	0.0808 (0.0396)	0.8536 (0.0096)
Total Number of employers during the post-boom period (normalized by # of quarters))	0.1010 (0.0371)	0.1105 (0.0095)
Total quarters of employment during the pre-boom, boom, and post-boom periods	30.8543 (8.7615)	0.0089 (0.0002)
Total quarters of employment during the pre-boom, boom, and post-boom periods squared	1028.753 (488.9757)	-0.00002 (0.0000)
Constant		1.6824 (0.0148)

R^2		0.5652
Sample Size		1,251,209

Note: All variables are significant at the 99 % confidence level except the (pre-boom earnings*pre-boom software and computer services) interaction term, the (boom service industry) indicator, the (post-boom IT Manufacturing industry) indicator, and the (pre-boom earnings*post-boom IT Manufacturing) interaction term. Manufacturing is the excluded sector category in all three time periods.

Appendix C: Boom/ Post-Boom Transition Frequencies

Post-Boom Industry

Boom Industry	IT Manufacturing	IT Software & Computer Services	IT Comm. Services	Non-IT Service	Non-IT Manufacturing	Construction
IT Manufacturing	7,908	612	268	2,747	1,307	138
IT Software & Computer Services	294	30,175	1,072	11,360	686	400
IT Comm. Services	257	1,740	28,279	6,100	364	474
Non-IT Service	1,170	10,387	5,593	712,285	23,529	13,237
Non-IT Manufacturing	759	1,687	1,014	53,070	248,440	6,182
Construction	34	290	385	11,264	2,673	65,047