

# **Employment and Earnings on the Technology Roller Coaster: Insight from State Administrative Data**

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## **Abstract**

This paper uses ten years of linked employee-employer administrative data from the state of Georgia to examine workers' earnings and employment experience through the information technology (IT) sector's employment boom of the mid-1990s and bust in the early 2000s. The results indicate that employment in the IT sector did not guarantee higher earnings post-boom. Further, IT employment opportunities pulled individuals into the IT sector by a significantly greater amount than individuals were entering other sectors during the boom, but the IT bust did not result in an analogous push of individuals out of the workforce.

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## I. Introduction

As roller coasters go, the technology sector labor market has provided quite a ride. The rise in employment during the information technology (IT) boom of the 1990s was followed by a dramatic drop in the early 2000s. This paper makes use of unique state administrative data from Georgia to dissect the impact of the IT boom and bust on the employment and earnings of workers in the IT sector.

While the IT sector is not the first labor market to experience extremes in employment (recall the ups and downs in the engineering industry during the 1970s), the double-digit growth followed by the double-digit decline experienced in the IT sector appears to have been unprecedented. Such dramatic 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.

This paper addresses several questions pertaining to the experience of workers during the rapid growth and subsequent decline of the IT sector in Georgia. These questions are: 1) Did working in the IT sector during the employment boom have a positive impact on earnings in the post-boom period? 2) Did the industry of employment in the post-boom period matter to the earnings outcome? and 3) Did the IT boom and bust

motivate workers to enter or leave the Georgia workforce in response to changing labor market opportunities?

This paper will first briefly document the nature of the IT roller coaster in the U.S. and in Georgia. It will then look at ten years worth of individual earnings in Georgia to evaluate how workers who worked in the IT sector fared during the post-IT boom period, relative to workers in other industries. Finally, there is an examination of the probability of a worker being attached to the Georgia labor force in the pre- and post-boom periods, given that they were employed in Georgia during the time period of the IT boom.

## II. The Information Technology Employment Roller Coaster

### A. 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 number of workers in IT industries in the U.S. (dashed heavy line) increased by close to 50 percent, almost two and a half times as fast as employment in non-IT producing industries (dashed light line). By 2000 there were some 5.4 million IT workers in the U.S., representing 4.9 percent of private sector employment.<sup>1</sup>

[Figure 1 here]

Since 2000 this pattern of rapid growth has reversed. During the 2001 recession (the gray shaded area) there was a widespread decline in business investment spending that led to layoffs in most IT-producing industries. Since the end of the recession both a

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<sup>1</sup> Bureau of Labor Statistics, Census of Employment and Wages ([www.bls.gov/cew](http://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.

more cautious approach to IT spending and the foreign outsourcing of IT work contributed to an ongoing weak job market for IT workers in the U.S. as a whole. From 2000 to 2003 employment in IT producing industries declined by 20 percent, compared to a 2.7 percent decline for all private sector industries. In 2003, there were some 1.1 million fewer workers at IT-related establishments in the U.S. than in 2000.

However, the rapid growth and decline in employment has not been uniform across IT-producing industries. As displayed in Table 1, IT manufacturing employment (employment in Computer Hardware and Communications Equipment combined) grew by 16.8 percent between 1993 and 2000, compared with a 1.0 percent growth in non-IT manufacturing. IT manufacturing employment then declined by almost 30 percent from 2000 to 2003, while non-IT manufacturing employment declined by 17.5 percent. Employment in IT service producing industries (establishments providing Software and Computer/Communications Services) increased by 67.5 percent between 1993 and 2000, compared with a 18.2 percent increase in non-IT private sector service industries. From 2000 to 2003, employment in IT services declined by 16.4 percent, while non-IT private sector service employment remained flat.

[Table 1 here]

### B. The Georgia Experience

In general, the labor market trends in Georgia tend to closely mirror that of the U.S. as a whole, suggesting that inferences about Georgia's experience are likely to be broadly representative of the U.S. as a whole (see Figure 1 and Table 2). Between 1993 and 2000 IT employment in Georgia increased by 65.3 percent. Employment growth in Georgia's Software & Computer Services and Computer Hardware industries was

especially strong during the 1993-2000 period. However, from 2000 to 2003, Georgia experienced, as did the U.S. as a whole, an almost 20 percent decline in IT employment. This resulted in 40,000 fewer IT workers in Georgia in 2003 relative to 2000, although there was still a net gain of 40,000 workers since 1993. In 2003, IT employment represented around 5 percent of private sector employment in Georgia, with the largest share of workers located in the Software & Computer Services industry.

[Table 2 here]

### III. The Data and Sample Construction

The two data sources used for the analysis come from state administrative data collected by the Georgia Department of Labor for the purposes of administering the state's Unemployment Insurance (UI) program. This program provides almost a complete census of employees on nonfarm payrolls, with information available on roughly 97 percent of nonfarm employees. The Individual Wage file contains information on a worker's quarterly earnings. Regrettably, the file contains no additional information about the worker's demographics (e.g., education, gender, race) 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 and linked to an employer file through a worker ID number.<sup>2</sup> These data are highly confidential and strictly limited in their distribution.

The employer file contains records on all UI-covered firms and includes quarterly information on the firm's level of employment and wages (total payroll) for the quarter, as well as the firm's NAICS classification.<sup>3</sup> Because of the low level of UI coverage in

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<sup>2</sup> See Haltiwanger et al. (1999) for a collection of studies using these and other employer-employee matched data sets.

<sup>3</sup> White et al. (1990) provide an extensive discussion about the use of these employment data, commonly referred to as the ES202 file. These are the UI data being used by the BLS to construct the Business

the agriculture industry (48% of employees working in agriculture), workers in agriculture are excluded from the analysis. In addition, since government workers have been found to be quite distinct from private workers in their rates of pay, turnover, and sensitivity to economic conditions (McConnell et al. 2003), they are also excluded from the analysis.

Another shortcoming of these data is that the individual wage file is linked to the employer identifier rather than the establishment identifier. Thus, since multiple establishments within a firm can have different NAICS codes, a choice of which NAICS code to assign to each worker who was employed by a multi-establishment firm is required. This analysis employs the same convention as the Department of Labor; the 6-digit NAICS code is assigned based on where the largest share of the firm's employment fell.

There are several reasons a worker doesn't make it into the final analysis. The first is if the worker's identifier is miscoded in the ES202 file or if the same identifier was included multiple times on one employer's quarterly payroll report. Additionally, quarterly earnings are top-coded at \$100,000, so workers were dropped if their nominal earnings were equal to \$100,000.

The focus of this research is primarily on the earnings experience of full-time employees. However, a limitation of the data is that there is no information on the starting date of employment (other than the quarter it occurred) or how many hours the employee worked for the firm. Thus, the sample is restricted to those who have real

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Employment Dynamics data file introduced at a BLS briefing 30 September 2003 (NEWS 2003). These firm level data are what were used to construct Figure 1 and Table 2 in this paper.

earnings that are at least \$3,000 per quarter, in an attempt to capture full-time workers.<sup>4</sup> Furthermore, a worker in a given quarter is only included in the analysis if they worked for the same employer in the previous quarter and the following quarter. Utilizing only interior quarters of earnings increases the likelihood that the individual was continuously employed by the same employer for the full quarter.

It is also impossible to identify in the data whether multiple employers during a quarter reflected simultaneous or sequential employment activity, thus records for only one employer per worker per quarter is retained. The employer that is used is the employer from which the worker received his/her greatest earnings during that quarter, thus increasing the chance that what is being captured is full employment during the quarter.

As shown in Figure 1, the boom period for IT workers ended in the fourth quarter of 2000, thus resulting in a post-boom period from the first quarter of 2001 to the date of the most recent data available, the fourth quarter of 2003. The beginning of the boom period is much less clearly defined. During 1995, the growth in IT employment began to deviate from the growth in other sectors of the labor force, with this deviation occurring slightly earlier in Georgia than in the U.S. However, for the sake of symmetry with the post boom period, the pre-boom period is defined as all quarters from 1993 through 1995.

Over each of these periods a worker has multiple possible activities. The worker can be absent from the data set, be working for one employer through the whole period, or working for multiple employers during the whole period. A worker's modal activity, absent or employed, is defined as that activity in which he/she is observed during most of

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<sup>4</sup> To adjust for inflation all dollar values are deflated using the PCE chain-type deflator (normalized to 2003 dollars).

the quarters of the period. The worker's modal NAICS is the industry 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.<sup>5</sup> These concepts of modal activity, modal earnings, and modal industry are used to collapse the 10 years of panel data into a single cross-section which describes an individual's primary activity and characteristics between 1993 and 2003.<sup>6</sup>

#### IV. Sample Characteristics

Sample means for the variables used in the analysis are included in Appendix C, Column 1. On average, workers in the post-IT boom period in Georgia had 19.5 quarters of Georgia labor market experience, which is defined as the number of interior quarters of employment in Georgia. On average, workers in both the boom and post-boom time periods had just slightly more than one employer in any given quarter. Job mobility within each time period is measured by the total number of unique employers a worker had during a time 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 number of employers) during the post-boom period.<sup>7</sup> This suggests that employment was slightly more stable during the boom period than during the post-boom period.

Approximately 40 percent of workers who are working in the post-boom time period were absent from the Georgia wage files in the pre-boom period. Dummy

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<sup>5</sup> 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.

<sup>6</sup> A full-blown fixed-effects panel data model was also estimated on individual quarterly observations over 10 years. That specification, however, did not add any information over the current two period specification described below.

<sup>7</sup> This characteristic is calculated by dividing the total number of unique employers by the total number of quarters during the period. If a worker has one employer during each period, his/her average number of employers will be 0.05 (1/20) during the boom and 0.08 (1/12) during the post-boom period.

variables are included to denote whether the worker was earning money in Georgia during the pre-boom period as well as to indicate any industry transitions that took place between the boom and post-boom periods. In any given industry, the majority of workers were employed in the same industry during the boom and post-boom periods.

The average real quarterly earnings for workers by their industry in the boom and post-boom periods are included in Table 3. In general, workers in the IT sector have higher wages than workers in non-IT industries. Furthermore, for the workers who were not in the IT sector during the boom, the average wage was higher during the boom period for those workers who moved into the IT sector post-boom.

[Table 3 here]

#### V. Individual Earnings Regression Analysis

The goal of this analysis is to determine whether being a participant in an IT industry resulted in any post-boom earnings advantage. Variations in workers' average modal earnings during the post-boom period are modeled as a function of pre-boom, boom, and post-boom employment activity:

$$LW_{i,t+1} = \beta_0 + \beta_1 X_i + B_2 I_{j,t} I_{k,t+1} + \beta_3 LW_{i,t} + B_4 LW_{i,t} I_{j,t} I_{k,t+1} + \varepsilon_{i,t+1}. \quad (1)$$

The dependent variable is the log of an individual's average quarterly earnings during the post-boom period while employed in the worker's modal industry.  $X_i$  includes information on multiple job holdings (average number of employers per quarter), total Georgia labor market experience, number of employer changes in both the boom and post-boom time periods, and an indicator that is equal to one if absent during the pre-boom period. The  $I_{j,t} I_{k,t+1}$  term is an indicator variable for the individual's industry transition path from industry  $j$  during the boom to industry  $k$  during the post-boom, which

allows for the return to the boom period industry choice to vary by industry choice in the post-boom time period.  $B_2$  is the vector of coefficients for these transition paths.

In order to capture individual fixed effects, the individual's boom period log modal earnings are included as a regressor. This added-value approach to controlling for individual fixed effects has been applied in the education literature.<sup>8</sup> As expected, there is a strong correlation between boom earnings and post-boom earnings, although boom earnings are not sufficient to explain all of the variation in post-boom earnings across individuals.

The boom log wage is also interacted with the industry transition paths  $(LW_{i,t}I_{j,t}I_{k,t+1})$ , in order to capture a more detailed measure of the individual fixed effects. This interaction allows the impact of the transition path on post-boom earnings to vary by individual earnings experiences during the boom period. This is important if, for example, high-earning individuals were more likely to follow a specific transition path. Not controlling for potential path dependence of earnings would lead one to conclude that this particular transition led to higher post-boom earnings when in fact it was just higher earning workers who chose that path.

The estimated marginal effects on wages of working in industry  $j$  during the boom period, by post-boom industry employment, are contained in Table 4, Column 1.<sup>9</sup> The boom and post-boom industry combinations are relative to the base case of an individual being employed in the manufacturing industry during both the boom and post-boom time periods.

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<sup>8</sup> See Zoghi et al. (2004) for a similar labor market application of the added-value methodology supported by Todd and Wolpin (2003).

<sup>9</sup> The full results from the OLS estimation are in Appendix C, Column 2.

Hotchkiss et al. (2004) found that workers that are hired by a firm while the firm is downsizing experience a significant earnings boost. Here, individuals that either entered the IT sector or changed from one IT industry to another in the post-boom period had the greatest return to wages in both periods, with individuals entering the Communication Services Industry experiencing the largest returns. IT workers that remained in the same IT industry in the post-boom period experienced positive but relatively low industry returns.

[Table 4 here]

Conversely, moving from any IT industry to a non-IT industry did not result in any systematic benefit over workers from other industries, and in some cases, there was a negative return to IT experience. For example, individuals who worked in Communication Services during the boom period and a non-IT sector post-boom experienced large negative returns to their IT experience relative to the base case. This result, combined with the high benefit to moving into Communication Services, is suggestive of a higher degree of industry specific human capital in Communication Services relative to other industries.

There are two possible explanations for this lack of return to having been in the IT sector. The more general observation is that the workers exiting a declining industry received a wage penalty relative to other workers, potentially as result of the involuntary nature of the job change.<sup>10</sup> Alternatively, the lack of a wage benefit could indicate that there is little long-term benefit to having been employed in the IT sector because there were no general skills acquired that transferred to other industries.

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<sup>10</sup> This is similar to the result found in Hotchkiss, Pitts, and Robertson (2004).

The importance of controlling for individual fixed-effects and potential systematic selection into the different industry transition paths, is evident from comparing the marginal effects in Column 1 of Table 4 with the parameter estimates without the boom wage controls in Column 2. The results in Column 2 lead to the conclusion that working in the IT sector resulted in significant wage gains, regardless of the individual's employment path. The much smaller effects in Column 1, however, suggest that there are significant human capital differences (as opposed to industry-specific differences) that lead to higher measured earnings of those who touched the IT sector.

Individuals that were not working in Georgia during the pre-boom period earned higher wages post-boom (see Appendix C). This is consistent with human capital theory which suggests that workers will make more expensive job changes (presumably moving from out of state) only if they are compensated for such an investment. Those not working in Georgia during the pre-boom period could have been nonworking residents of Georgia such as students, the unemployed, or non-labor market participants, or new migrants to Georgia. The higher wages suggest that those who were absent from the pre-boom time period are comprised mostly of new migrants as new graduates and re-entrants would have less labor market experience and would likely earn lower wages.

Also 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 both the boom and post-boom periods, although the return was greater during the boom. This suggests that workers are able to chase higher wages by switching employers, especially during the boom. 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 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 post-boom period, suggesting that workers are trying to make up for lower wages in their primary job by working multiple jobs.<sup>11</sup>

## VI. Who Came and Who Left?

The rise and fall of labor market conditions motivates workers to migrate to take advantage of promising labor market opportunities and to escape labor market declines. The human capital investment theory assumes that a worker migrates, or changes jobs, in order to capitalize on his/her human capital endowment.<sup>12</sup> Consequently, we typically observe that job changers experience the fastest earnings growth over time (Hotchkiss et al. 2004). The nine percent wage advantage seen in the previous section experienced by workers who migrated into Georgia is further evidence of this phenomenon.<sup>13</sup> This section explores whether workers potentially migrated into Georgia to take advantage of the IT boom and whether IT workers (more than workers from other sectors) migrated out of Georgia after the boom, during a period of dramatic decline in IT sector employment opportunities.

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<sup>11</sup> This suggests that this variable may be endogenous. This will be examined in more detail in the future.

<sup>12</sup> Mincer and Jovanovic (1981) is the classic analysis that firmly places migration into the context of human capital investment.

<sup>13</sup> Recall that the workers who are absent in the Georgia wage file in any period may or may not be actually absent from Georgia. Anyone living in Georgia but unemployed or out of the labor force will also be absent from the wage file.

Table 5 contains the marginal effects of worker characteristics during the IT boom on the probability of being absent from Georgia's workforce pre-boom and the probability of not working in Georgia post-boom.<sup>14</sup> The full results from the probit model estimations are found in Appendix D. This analysis indicates whether the IT boom pulled workers into Georgia's workforce with a higher probability than workers were migrating into other sectors, holding constant their earnings and turnover tendency. In addition, the post-boom analysis indicates to what extent the IT bust pushed workers out of the Georgia workforce.<sup>15</sup>

[Table 5 here]

Looking first at the probability of entry, we see that Computer Manufacturing workers' probability of entry is practically the same as that of non-IT Manufacturing workers (the excluded group). The probability that a worker in the Software and Computer Services sector was absent from the Georgia workforce pre-boom is 22 percentage points greater than the probability that a worker in the Manufacturing sector was absent. Workers in the Construction industry, which also experienced strong employment growth during the boom period, had the next highest probability of entering the Georgia workforce. These were followed by Communication Services and non-IT Service workers. Among IT workers, those in the Software and Computer Services

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<sup>14</sup> Using the estimated coefficients from a probit specification, the marginal effects for a change in a dummy variable are estimated by calculating the probability of the outcome of interest for the dummy variable equal to zero and then set equal to one, and then taking the difference in the calculated probabilities. The individual marginal effects are then averaged across the sample. This method of calculating the marginal effect of a change in a dummy variable is referred to as a measure of discrete change and is described in greater detail by Long (1997: 135-8).

<sup>15</sup> The pull on workers to communities experiencing positive economic opportunities and the push of workers out of communities experiencing economic declines has been referred to as "push-pull" migration, and has been analyzed in a variety of different contexts. One of the earliest treatments was Thornthwaite (1934). Also see Blevins (1969), Zimmermann (1996), Boyd (2002), and Kyriakouides (2003).

industry seemed to have been the most likely to respond to the potential gains in the Georgia labor market from the IT boom.

It is also of interest to note that workers that experienced greater turnover activity (number of different employers) during the boom were less likely (by 10 percentage points) to have been absent pre-boom. This suggests that individuals came to work in Georgia for a specific job, rather than moving for whatever opportunities they might have found. The negative impact of higher earnings on the probability of having been absent may be a reminder that when we refer to workers that were absent from the Georgia labor market pre-boom, not only does that group include in-migrants, but it also includes new entrants and reentrants living in Georgia, who are likely on the lower end of the earnings distribution. This negative marginal effect may also merely be confirming that higher paid workers are less likely to change jobs, *ceteris paribus*, than lower paid workers.

Table 5 also suggests that positive economic conditions provided a much stronger pull into a workforce than negative conditions pushed them out. The smaller marginal effects in the second column indicate that workers are much less likely to be absent post-boom than they were to have been absent pre-boom, regardless of the sector in which they were employed during the boom. Nicci et al. (2002) find that civic attributes of a community act as a counter-veiling force against economic push factors that might drive workers away from a declining labor market. Georgia may have had the civic attributes of Atlanta (where much of IT employment was located) working in its favor for the retention of highly-skilled workers that were pulled into the state during the boom. Further evidence of the weakness of push-migration lies in the relative magnitude of the

marginal effects across sectors. Whereas the disproportionate growth in Software and Computer Services resulted in a dramatically larger impact in pulling workers into the Georgia labor market, the exit of these workers is similar to the exit of workers from other sectors--sectors that experienced a more moderate decline post-boom than did the Software and Computer Services sector. The large exodus of workers in the construction industry is also consistent with the large decline in nonresidential construction that has occurred in Georgia since 2000 and suggests that these workers have the least transferable skills to other industries.<sup>16</sup>

The negative marginal impact of higher earnings on the probability of exiting Georgia's workforce is consistent with the notion that higher paid workers are less likely to change jobs, as mentioned above. Furthermore, the finding that workers who were absent from the Georgia workforce pre-boom are five percent more likely to leave the Georgia workforce post-boom is consistent with the idea that some workers experience a lower cost to migration, *ceteris paribus*, or are willing to take on greater amounts of risk.

## V. Summary

The analysis indicates that simply being employed in the IT sector during the IT boom period did not, in itself, have a positive influence on an individual's earnings. In general, workers whose modal employment during the boom was in the IT sector and who subsequently worked in the non-IT sector experienced lower post-boom earnings than their industry counterparts who worked elsewhere in Georgia during the boom.

There were, however, large gains associated with continuing employment in the two IT

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<sup>16</sup> It is not unreasonable to extract from these results the possibility that the decline in nonresidential construction activity in Georgia since 2000 could be related to the IT bust. This is, however, a direction for future research.

service producing sectors as well as with entering the IT sector as a whole in the post-boom period.

The IT boom appears to have pulled workers to Georgia to take advantage of the increase in IT employment opportunities. The pull was especially strong into the Software & Computer Services industry. The decline of the IT sector did not result in an analogous push of individuals out of the Georgia workforce. As a result of the boom in Georgia's IT sector, there was a net migration of skilled workers to the state.

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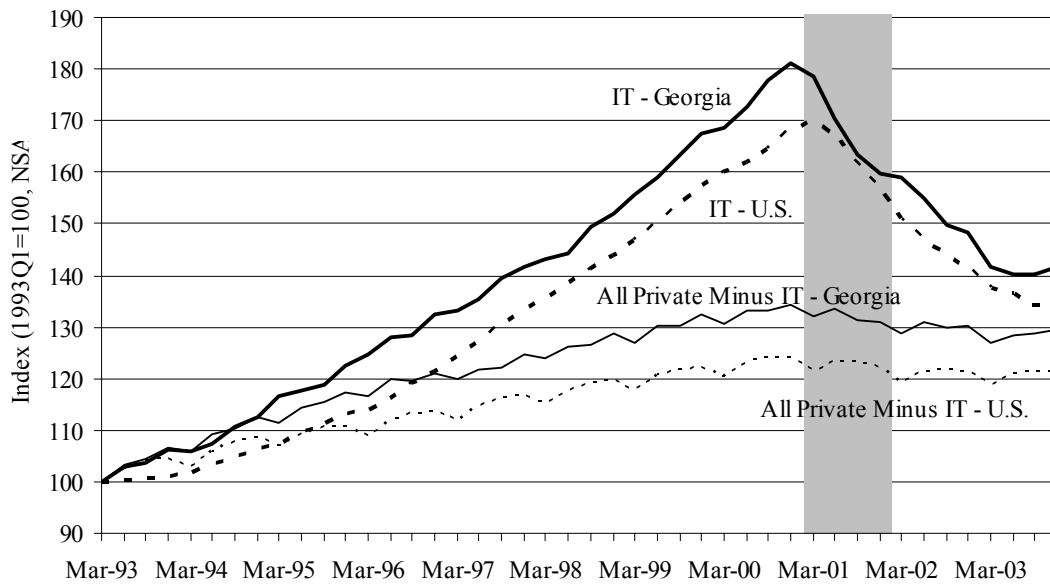
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**Figure 1. Georgia and U.S. Employment Indices: IT and All Private Minus IT (1993Q1=100, NSA).**



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

**Table 1. U.S. IT Employment Trends.**

Sectors	Employment (‘000) Annual Average			% Change	
	1993	2000	2003	93-00	00-03
Computer Hardware	982.0 (1.1)	1170.3 (1.1)	847.6 (0.8)	19.8	-27.6
Software & Computer Services	1493.3 (1.6)	2701.4 (2.5)	2234.7 (2.1)	89.1	-17.3
Communications Equipment	305.2 (0.3)	320.6 (0.3)	200.7 (0.2)	7.1	-37.4
Communications Services	944.7 (1.0)	1253.1 (1.1)	1073.2 (1.0)	34.5	-14.4
IT Manufacturing (Computer Hardware and Communications Equipment)	1287.2 (1.4)	1490.9 (1.4)	1408.3 (1.0)	16.8	-29.7
IT Services (Software & Computer Services and Communications Services)	2438.1 (2.6)	3954.5 (3.6)	3307.9 (3.1)	67.5	-16.4
All IT-Producing Industries	3725.3 (4.0)	5445.3 (4.9)	4356.2 (4.1)	49.7	-20.0
Non-IT Manufacturing	15662.8 (16.7)	15823.1 (14.4)	13062.7 (12.2)	1.0	-17.5
Non-IT Private Service Industries	67992.9 (72.3)	80395.5 (73.1)	80972.1 (75.6)	18.2	0.7
Construction Industries	4779 (5.3)	6788 (6.2)	6722 (6.3)	42.0	-1.0
All Private Industries	94,046	110,024	107,078	20.7	-2.7

Note: Numbers in parentheses are shares of total private sector employment.

Source: Bureau of Labor Statistics, Census of Employment and Wages

([www.bls.gov/cew](http://www.bls.gov/cew)).

**Table 2. Georgia IT Employment Trends**

Sectors	Employment ('000) Annual Average			% Change	
	1993	2000	2003	93-00	00-03
Computer Hardware	6.33 (0.2)	10.06 (0.3)	6.63 (0.2)	58.9	-34.1
Software & Computer Services	61.53 (2.4)	117.96 (3.6)	98.81 (3.1)	91.7	-16.2
Communications Equipment	8.97 (0.4)	9.29 (0.3)	6.65 (0.2)	43.1	-22.8
Communications Services	46.57 (1.8)	66.63 (2.0)	51.43 (1.6)	3.5	-28.4
IT Manufacturing (Computer Hardware and Communications Equipment)	15.31 (0.6)	19.34 (0.6)	13.74 (0.4)	26.4	-31.4
IT Services (Software & Computer Services and Communications Services)	108.10 (4.2)	18.46 (5.6)	15.02 (4.8)	70.8	-18.6
All IT-Producing Industries	123.41 (4.8)	203.94 (6.2)	163.52 (5.2)	65.3	-19.8
Non-IT Manufacturing	502.69 (19.7)	514.66 (15.53)	437.26 (13.8)	3.2	-15.6
Non-IT Private Service Industries	1,867 (68.9)	2,526 (75.7)	2,486 (77.9)	35.4	-1.6
Construction Industries	127.3 (5.0)	204.4 (6.2)	195.4 (6.2)	60.57	-4.40
All Private Industries	2,552	3,314	3,174	29.9	-4.2

Note: Numbers in parentheses are shares of total private sector employment.

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

**Table 3. Quarterly Real Earnings: Boom and Post-boom Periods**

	<b>Number of observations</b>	<b>Boom Mean (std. dev.)</b>	<b>Post Boom Mean (std. dev.)</b>
<i>IT Manufacturing Post Boom</i>			
IT Manufacturing Boom	11,289	\$12,632.58 (8299.812)	\$13,638.14 (9093.766)
Software and Computer Services Boom	539	14,819.26 (8545.956)	17,861.36 (9003.664)
Communication Services Boom	398	21,689.37 (8380.790)	21,490.92 (8684.236)
Construction Boom	67	8,938.731 (4169.608)	10,477.7 (5312.873)
Service Boom	2,214	10,100.86 (7870.906)	12,056.7 (8164.774)
Manufacturing Boom	1,129	9,640.658 (5969.202)	10,656.57 (6766.542)
<i>Software and Computer Services Post Boom</i>			
IT Manufacturing Boom	902	15,973.85 (9099.492)	19,715.03 (10144.060)
Software and Computer Services Boom	53,867	17,261.31 (9561.178)	19,421.15 (10373.140)
Communication Services Boom	2,561	17,797.63 (8041.440)	20,152.89 (9103.851)
Construction Boom	578	10,099.02 (6442.461)	12,803.38 (7760.618)
Service Boom	19,347	11,915.72 (8593.857)	15,128.99 (9564.284)
Manufacturing Boom	2,660	11,463.92 (6741.924)	14,176.51 (8899.082)
<i>Communication Services Post Boom</i>			
IT Manufacturing Boom	372	10,675.21 (5831.644)	14,465.35 (7086.419)
Software and Computer Services Boom	2,129	14,878.23 (7999.519)	17,974 (7777.019)
Communication Services Boom	40,946	14,547.27 (6948.021)	15,799.8 (7670.864)
Construction Boom	724	9,059.907 (4685.484)	12,635.91 (6767.987)
Service Boom	11,762	8,841.55 (6289.809)	12,361.11 (7059.384)
Manufacturing Boom	1,634	8,730.53 (4718.619)	11,137.36 (5433.472)
<i>Manufacturing Post Boom</i>			
IT Manufacturing Boom	1,740	9,011.69	9,823.56

		(4528.202)	(5557.066)
Software and Computer Services Boom	1,301	12,224.9 (7645.891)	13,605.89 (7460.249)
Communication Services Boom	572	11,715.86 (7196.949)	11,558.29 (8441.279)
Construction Boom	5,126	7,028.86 (3764.286)	8,098.08 (4108.840)
Service Boom	44,833	7,490.49 (5538.097)	8,822.17 (5920.386)
Manufacturing Boom	351,925	9,297.08 (5813.052)	9,682.98 (6329.822)
<i>Service Post Boom</i>			
IT Manufacturing Boom	4,049	10,375.74 (6890.836)	11,209.04 (8493.620)
Software and Computer Services Boom	21,075	13,612.51 (8956.670)	14,871.73 (9805.532)
Communication Services Boom	10,328	12,807.08 (7638.139)	12,054.77 (8784.153)
Construction Boom	21,734	7,828.37 (4604.209)	8,561.75 (5443.449)
Service Boom	1,269,117	9,225.48 (7072.585)	10,216.11 (7949.380)
Manufacturing Boom	80,736	7,917.33 (5283.793)	7,906.15 (5856.436)
<i>Construction Post Boom</i>			
IT Manufacturing Boom	200	9,689.81 (4978.026)	10,119.73 (5365.275)
Software and Computer Services Boom	711	11,524.25 (7312.332)	11,493.13 (7057.390)
Communication Services Boom	699	14,128.08 (7341.733)	12,067.9 (6972.485)
Construction Boom	115,812	9,268.42 (5268.605)	9,992.61 (5900.281)
Service Boom	24,800	7,709.66 (4962.352)	8,830.13 (5457.162)
Manufacturing Boom	10,142	7,432.71 (3841.967)	7,572.04 (4007.055)

Note: Dollar values are deflated using the PCE chain-type deflator (normalized to 2003 dollars).

**Table 4. Impact of Industry Transition on Post-boom Earnings**

<b>Specification:</b>	<b>Includes Boom Wage and Boom Wage Interacted with Industry Transitions</b>	<b>Excludes Boom Wage</b>
<i>IT Manufacturing Post Boom</i>		
IT Manufacturing Boom	0.0388 (0.0028)	0.2757 (0.0050)
Software and Computer Services Boom	0.1964 (0.0133)	0.7218 (0.0228)
Communication Services Boom	0.0216 (0.0148)	0.8945 (0.0265)
Construction Boom	0.1126 (0.0373)	0.2740 (0.0645)
Service Boom	0.1758 (0.0064)	0.3013 (0.0113)
Manufacturing Boom	0.0530 (0.0086)	0.1288 (0.0157)
<i>Software and Computer Services Post Boom</i>		
IT Manufacturing Boom	0.2095 (0.0100)	0.7687 (0.0176)
Software and Computer Services Boom	0.1189 (0.0015)	0.7367 (0.0024)
Communication Services Boom	0.1228 (0.0060)	0.8472 (0.0105)
Construction Boom	0.2192 (0.0135)	0.4334 (0.0220)
Service Boom	0.2533 (0.0025)	0.5379 (0.0039)
Manufacturing Boom	0.1599 (0.0057)	0.4197 (0.0103)
<i>Communication Services Post Boom</i>		
IT Manufacturing Boom	0.2844 (0.0154)	0.5055 (0.0274)
Software and Computer Services Boom	0.2235 (0.0072)	0.7790 (0.0115)
Communication Services Boom	0.0838 (0.0017)	0.5591 (0.0028)
Construction Boom	0.3206 (0.0123)	0.4486 (0.0196)
Service Boom	0.3516 (0.0032)	0.4002 (0.0050)
Manufacturing Boom	0.2215 (0.0079)	0.2740 (0.0131)

<i>Manufacturing Post Boom</i>		
IT Manufacturing Boom	0.0363 (0.0070)	0.0678 (0.0127)
Software and Computer Services Boom	0.1136 (0.0089)	0.4664 (0.0147)
Communication Services Boom	-0.0688 (0.0132)	0.2449 (0.0221)
Construction Boom	0.1202 (0.0044)	0.0695 (0.0074)
Service Boom	0.1541 (0.0016)	0.0572 (0.0027)
Manufacturing Boom (excluded group)		
<i>Service Post Boom</i>		
IT Manufacturing Boom	-0.0074 (0.0045)	0.1572 (0.0084)
Software and Computer Services Boom	0.0639 (0.0022)	0.5004 (0.0038)
Communication Services Boom	-0.1230 (0.0032)	0.2902 (0.0053)
Construction Boom	0.0594 (0.0022)	0.0923 (0.0037)
Service Boom	0.0694 (0.0005)	0.0852 (0.0010)
Manufacturing Boom	-0.0479 (0.0011)	-0.0941 (0.0021)
<i>Construction Post Boom</i>		
IT Manufacturing Boom	0.0258 (0.0226)	0.1842 (0.0373)
Software and Computer Services Boom	0.0062 (0.0129)	0.3203 (0.0198)
Communication Services Boom	-0.1658 (0.0132)	0.3386 (0.0200)
Construction Boom	0.0602 (0.0010)	0.1702 (0.0018)
Service Boom	0.1324 (0.0021)	0.1228 (0.0035)
Manufacturing Boom	0.0076 (0.0033)	-0.0114 (0.0053)

Note: All variables are significant at the 99 percent confidence level. Manufacturing in boom and post-boom time periods is the excluded transition category. The impact in the first specification is the marginal effect evaluated at the average log boom wage for workers in the specific transition category. The variance for the marginal effects are calculated via the Delta method, assuming  $\hat{B}_4$  and  $\overline{LW}_t$  are uncorrelated:

$$\hat{V}(\hat{B}_2 + \hat{B}_4 \overline{LW}_t) \cong \hat{V}(\hat{B}_2) + \overline{LW}_t^2 \hat{V}(\hat{B}_4) + B_4^2 \hat{V}(\overline{LW}_t) + 2\overline{LW}_t \hat{V}(\hat{B}_2, \hat{B}_4).$$

**Table 5. Marginal Effects from Probit Estimation of Being Absent from the Georgia Workforce Pre- and Post-Boom.**

	<b>Probability of Entry</b>	<b>Probability of Exit</b>
Number of different employers during the boom	-0.1008	-0.1408
Log average earnings during the boom	-0.2010	-0.0999
Absent from Georgia wage file pre-boom	--	0.0522
Manufacturing IT during the boom	-0.0013	-0.0332
Software and Computer Services during the boom	0.2158	0.0342
Communication Services during the boom	0.1415	-0.005
Construction (non-IT) during the boom	0.1636	0.0870
Service (non-IT)	0.1199	0.022

Note: Manufacturing (non-IT) is the excluded sector category. Entry means that the worker was absent from the Georgia wage files for most of the pre-boom time period. Exit means that the workers was absent from the wage files for most of the post-boom period. An absence could mean the person is living in Georgia and is either unemployed or not in the labor force, or the person is working or not working outside of Georgia.

**Appendix A: Information technology sector NAICS Definitions and Classifications.**

<b>IT NAICS Industry Definition</b>	<b>NAICS</b>
<b>Technology Manufacturing</b>	
<i>Computer Hardware (CH)</i>	
Electronic computers	334111
Computer storage devices	334112
Computer terminals	334113
Other computer peripheral equipment	334119
Electron tubes	334411
Bare printed circuit boards	334412
Semiconductors and related devices	334413
Electronic capacitors	334414
Electronic connectors	334417
Printed circuit assemblies	334418
Miscellaneous electronic components	334415,6,9
Industrial process variable instruments	334513
Electricity and signal testing instruments	334515
Analytical laboratory instruments	334516
Semiconductor machinery	333295
Office machinery	333313
<i>Communications Equipment (CE)</i>	
Telephone apparatus	334210
Broadcast and wireless communications equipment	334220
Audio and video equipment	334310
Fiber optic cable manufacturing	335921
Software reproducing	334611
Magnetic and optical recording media	334613
<b>Software and Computer Services (SCS)</b>	
Software publishers	511210
ISPs and web search portals	518111,2
Data processing and related services	518210
Computer and software wholesalers	423430
Computer and software retailers	443120
Custom computer programming services	541511
Computer systems design services	541512
Computer facilities management services	541513
Other computer-related services	541519
Office machine rentals and leasing	532420
Computer and office machine repair	811212
Computer Training Schools	611420

**Communication Services (CS)**

Wired telecommunications carriers	517110
Cellular and other wireless carriers	517212
Telecommunications resellers	517310
Cable and other program distribution	517510
Satellite and other telecommunications services	517410,910
Communications equipment repair and leasing	811213

Note: These classifications are based on Economics and Statistics Administration, *Digital Economy 2003*. Only slight modifications were made. For example, Computer Training Schools was added to the CSC classification, and Computer Software Wholesalers and Retailers were included in CSC instead of CH.

**Appendix B: Shares of Technology Sector Employment, the U.S. and Georgia.**

NAICS	U.S.			Georgia		
	1993	2000	2003	1993	2000	2003
<b>Computer Hardware</b>						
334111	15.9	13.4	14.4	15.1	17.1	3.3
334112	3.8	3.2	3.7	2.3	3.3	5.1
334113	1.7	2.1	2.1	5.6	3.0	4.8
344119	6.6	6.0	6.1	16.5	11.1	13.7
334411	2.2	1.7	1.5	0.0	0.0	0.0
334412	10.2	11.7	7.8	14.3	25.6	26.5
334413	19.5	24.5	26.6	1.9	3.0	1.6
334414	1.6	1.4	1.1	3.1	2.8	3.5
334415	1.0	0.8	0.7	0.0	0.0	0.0
334416	2.0	1.6	1.3	0.5	0.5	1.2
334417	1.7	2.1	1.8	1.8	1.6	1.7
334418	5.4	5.6	5.3	7.1	9.9	9.7
334419	8.1	8.2	7.8	5.7	4.3	5.7
334513	6.6	5.9	6.8	23.2	17.5	20.3
334515	7.5	5.6	5.5	0.3	0.2	0.6
334516	3.4	2.9	3.8	0.3	0.1	0.4
333295	1.3	1.9	2.0	0.2	0.3	0.3
333313	1.6	1.4	1.4	2.3	1.5	1.8
<b>Communications Equipment</b>						
334210	26.5	32.5	24.8	10.2	13.4	6.3
334220	39.5	34.1	38.5	52.1	36.2	36.9
334310	17.7	16.2	18.8	13.7	12.3	17.5
334611	7.2	8.4	9.4	11.0	15.4	12.9
334613	5.3	2.8	3.0	8.8	9.8	3.3
335921	3.8	6.0	5.5	4.2	13.0	23.1
<b>Software and Computer Services</b>						
511210	8.8	9.8	10.6	9.3	11.5	11.6
518111	2.4	6.3	4.9	3.3	7.3	8.1
518112	0.2	0.6	0.5	0.0	0.0	0.1
518210	17.5	12.0	12.6	16.7	11.1	11.6
423430	14.3	11.0	11.2	24.3	19.4	17.9
443120	10.7	8.2	7.2	6.3	4.1	3.4
541511	16.5	21.0	21.9	10.8	17.5	17.3
541512	16.0	19.5	20.0	9.5	13.3	15.3
541513	5.5	2.4	2.6	14.7	7.8	7.6
541519	4.0	5.5	5.1	1.7	4.7	4.4
532420	0.9	0.5	0.5	0.4	0.8	0.4

811212	2.5	1.8	2.0	2.5	1.7	1.6
611420	0.8	1.1	0.9	0.5	0.9	0.8
<b>Communications Services</b>						
517110	67.3	58.0	53.4	81.1	66.8	59.2
517212	5.0	12.1	15.5	5.4	11.4	17.9
517310	14.5	15.9	14.8	8.7	14.4	15.1
517510	8.8	9.9	12.4	3.9	6.3	6.5
517410	2.2	1.8	1.6	0.1	0.4	0.4
517910	0.6	0.7	0.8	0.0	0.1	0.2
811213	1.7	1.6	1.6	0.8	0.6	0.8

**Appendix C: Sample Means and  
OLS Log Wage Regression: Post-Boom Time Period**

	<b>Mean (std. dev.)</b>	<b>Coefficient (std. error)</b>
Log Quarterly Wage (dependent variable)	9.0632 (0.5897)	-
Absent from Georgia Labor Force Pre-Boom	0.3952 (0.4889)	0.0841 (0.0005)
Log Average Earnings during the boom	8.9835 (0.5684)	0.9430 (0.0010)
Average Number of employers in a given quarter during the boom period	1.0710 (0.2167)	0.0399 (0.0010)
Average Number of employers in a given quarter during the post-boom period	1.0593 (0.2104)	-0.0659 (0.0011)
Total Number of employers during the boom period (normalized by # of qtrs)	0.0776 (0.0378)	0.7246 (0.0058)
Total Number of employers during the post-boom period (normalized by # of qtrs)	0.1024 (0.0383)	0.0183 (0.0053)
Total quarters of employment during the boom and post period	19.4722 (8.2328)	0.0073 (0.0001)
Total quarters of employment during the boom and post period squared	446.9468 (306.7000)	0.0000 (0.0000)
<i>IT Manufacturing Post Boom</i>		
IT Manufacturing Boom	0.0053 (0.0728)	-0.5581 (0.0456)
Software and Computer Services Boom	0.0003 (0.0160)	2.3621 (0.2239)
Communication Services Boom	0.0002 (0.0137)	1.8117 (0.3312)
Construction Boom	0.0000 (0.0056)	2.3782 (0.7129)
Service Boom	0.0010 (0.0323)	1.7102 (0.0890)
Manufacturing Boom	0.0005 (0.0231)	0.7059 (0.1406)
<i>Software and Computer Services Post Boom</i>		
IT Manufacturing Boom	0.0004 (0.0206)	1.8366 (0.1712)
Software and Computer Services Boom	0.0254 (0.1574)	0.7194 (0.0237)
Communication Services Boom	0.0012 (0.0348)	2.1382 (0.1197)
Construction Boom	0.0003 (0.0165)	2.9480 (0.2105)

Service Boom	0.0091 (0.0951)	2.5785 (0.0313)
Manufacturing Boom	0.0013 (0.0354)	1.4067 (0.0949)
<i>Communication Services Post Boom</i>		
IT Manufacturing Boom	0.0002 (0.0133)	2.0924 (0.3083)
Software and Computer Services Boom	0.0010 (0.0317)	3.2483 (0.1127)
Communication Services Boom	0.0193 (0.1377)	0.8034 (0.0314)
Construction Boom	0.0003 (0.0185)	3.7145 (0.2111)
Service Boom	0.0056 (0.0743)	3.2762 (0.0434)
Manufacturing Boom	0.0008 (0.0278)	3.1618 (0.1416)
<i>Manufacturing Post Boom</i>		
IT Manufacturing Boom	0.0008 (0.0287)	1.1462 (0.1399)
Software and Computer Services Boom	0.0006 (0.0248)	2.6734 (0.1326)
Communication Services Boom	0.0003 (0.0164)	2.3275 (0.2061)
Construction Boom	0.0024 (0.0491)	3.1742 (0.0865)
Service Boom	0.0212 (0.1439)	2.3102 (0.0239)
Manufacturing Boom		
<i>Service Post Boom</i>		
IT Manufacturing Boom	0.0019 (0.0437)	0.3623 (0.0765)
Software and Computer Services Boom	0.0100 (0.0993)	1.6332 (0.0323)
Communication Services Boom	0.0049 (0.0697)	2.1196 (0.0492)
Construction Boom	0.0103 (0.1008)	2.4150 (0.0384)
Service Boom	0.5992 (.4901)	0.6225 (0.0096)
Manufacturing Boom	0.0381 (0.1915)	1.6760 (0.0202)
<i>Construction Post Boom</i>		
IT Manufacturing Boom	0.0001 (0.0097)	2.9162 (0.3985)

Software and Computer Services Boom	0.0003 (0.0183)	3.1637 (0.1753)
Communication Services Boom	0.0003 (0.0182)	3.6140 (0.2005)
Construction Boom	0.0547 (0.2274)	0.8850 (0.0185)
Service Boom	0.0117 (0.1076)	3.1661 (0.0337)
Manufacturing Boom	0.0048 (0.0690)	3.6426 (0.0623)
<b>Log Wage Interaction</b>		
<i>IT Manufacturing Post Boom</i>		
IT Manufacturing Boom		0.0643 (0.0049)
Software and Computer Services Boom		-0.2288 (0.0236)
Communication Services Boom		-0.1808 (0.0334)
Construction Boom		-0.2517 (0.0791)
Service Boom		-0.1703 (0.0099)
Manufacturing Boom		-0.0724 (0.0156)
<i>Software and Computer Services Post Boom</i>		
IT Manufacturing Boom		-0.1706 (0.0179)
Software and Computer Services Boom		-0.0625 (0.0025)
Communication Services Boom		-0.2080 (0.0123)
Construction Boom		-0.3007 (0.0232)
Service Boom		-0.2533 (0.0034)
Manufacturing Boom		-0.1355 (0.0103)
<i>Communication Services Post Boom</i>		
IT Manufacturing Boom		-0.1972 (0.0336)
Software and Computer Services Boom		-0.3192 (0.0119)
Communication Services Boom		-0.0759 (0.0033)
Construction Boom		-0.3770

		(0.0234)
Service Boom		-0.3280 (0.0049)
Manufacturing Boom		-0.3279 (0.0158)
<i>Manufacturing Post Boom</i>		
IT Manufacturing Boom		-0.1233 (0.0155)
Software and Computer Services Boom		-0.2767 (0.0143)
Communication Services Boom		-0.2599 (0.0223)
Construction Boom		-0.3484 (0.0099)
Service Boom		-0.2463 (0.0027)
Manufacturing Boom		
<i>Service Post Boom</i>		
IT Manufacturing Boom		-0.0407 (0.0084)
Software and Computer Services Boom		-0.1680 (0.0035)
Communication Services Boom		-0.2409 (0.0053)
Construction Boom		-0.2662 (0.0043)
Service Boom		-0.0619 (0.0011)
Manufacturing Boom		-0.1950 (0.0023)
<i>Construction Post Boom</i>		
IT Manufacturing Boom		-0.3187 (0.0439)
Software and Computer Services Boom		-0.3437 (0.0190)
Communication Services Boom		-0.4008 (0.0212)
Construction Boom		-0.0915 (0.0021)
Service Boom		-0.3442 (0.0038)
Manufacturing Boom		-0.4120 (0.0071)
Constant		0.3251 (0.0090)

R <sup>2</sup>		0.7676
Sample Size		2,118,018

Note: All variables are significant at the 99 percent confidence level except the number of different employers in the post boom time period. Manufacturing in boom and post-boom time periods is the excluded sector category. Absent refers to an absence from the Georgia administrative wage files. An absence could mean the person is living in Georgia and is either unemployed or not in the labor force, or the person is working or not working outside of Georgia.

**Appendix D: Probit Estimation of Absent from Georgia Pre- and Post-Boom.**

	Prob(Absent Pre)	Prob(Absent Post)
	Coef (se)	Coef (se)
Absent from Georgia Labor Force Pre-Boom		0.1532 (0.0016)
<i>Boom Industry</i>		
IT Manufacturing	-4.0608 (0.1359)	-2.3371 (0.1433)
Software and Computer Services	-1.7964 (0.0688)	-1.6995 (0.0720)
Communication Services	1.5231 (0.0969)	-1.9819 (0.0979)
Construction	0.9508 (0.0580)	0.9193 (0.0586)
Service	0.3768 (0.0320)	-0.7279 (0.0323)
Number of different employers during the boom	-0.2752 (0.0011)	-0.4172 (0.0012)
Log Average Earnings during the boom	-0.5513 (0.0033)	-0.3621 (0.0033)
<i>Interaction Terms</i>		
Log Average Earnings during the boom times IT Manufacturing	0.4558 (0.0148)	0.2517 (0.0156)
Log Average Earnings during the boom times Software and Computer Services	0.2669 (0.0073)	0.2023 (0.0077)
Log Average Earnings during the boom times Communication Services	-0.1273 (0.0103)	0.2213 (0.0104)
Log Average Earnings during the boom times Construction	-0.0566 (0.0065)	-0.0755 (0.0066)
Log Average Earnings during the boom times Service	-0.0052 (0.0036)	0.0896 (0.0036)
Constant	4.8589 (0.0290)	3.203 (0.0293)
n = 3,207,132		

Note: All coefficients are significant at the 99 percent confidence level. Sample includes all workers with earnings during the boom period. Manufacturing (non-IT) is the excluded sector category. Entry means that the worker was absent from the Georgia wage files for most of the pre-boom time period. Exit means that the workers was absent from the wage files for most of the post-boom period. An absence could mean the person is living in Georgia and is either unemployed or not in the labor force, or the person is working or not working outside of Georgia.