# Who Will Stay and Who Will Leave?

## A Report of the Southern Technology Council

May, 2001

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## Individual, Institutional and State-Level Predictors of State Retention of Recent Science and Engineering Graduates

### Policy and Research Recommendations


**By**

**Louis G. Tornatzky, Ph.D**
**Senior Fellow, Southern Technology Council**

**Denis O. Gray, Ph.D.**
**Professor, Department of Psychology, North Carolina State University**

**Stephanie A. Tarant**
**Master's Candidate in Psychology, North Carolina State University**

**Cathy Zimmer, Ph.D.**
**Associate Professor, Department of Sociology, North Carolina State University**



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# EXECUTIVE SUMMARY

In this study of the migration behavior of science and engineering graduates at the master's and bachelor's levels, the odds of an individual taking a job in-state are shown to increase more than tenfold if the individual stays in the same state they went to high school in to attend college. This striking finding lends support to the recent wave of aggressive state-sponsored college scholarship initiatives.

Graduates are also more likely to end up employed in-state if they:

- are foreign students subsequently employed in the U.S.;
- majored in a field other than engineering or the physical sciences;
- were older than average for their class;
- attended a large college in a large metropolitan area; or
- attended college in a large state.

On the other side of the equation, graduates are less likely to be employed in-state if they:

- graduate in engineering and the physical sciences;
- have a high grade-point average;
- graduate from a research-intensive institution;
- graduate from a historically black college or university; or
- command an above-average starting salary upon graduation.

While a number of states have initiated aggressive scholarship programs for their own high school graduates, the study suggests that states might be well-served by lowering out-of-state tuition for "arrivers," those graduates of a state's institutions who attended high school elsewhere but stay in the state after college to work. If the goal is to increase the number of science and engineering graduates in the workforce, then an "arriver" is as important as a student who graduated from both high school and college in-state, and might beneficially be given similar financial consideration.

Policymakers throughout the nation are concerned with education and skill levels among workers. The capacity of a workforce to respond to the scientific and engineering needs of the marketplace is critical in the emerging, knowledge-based economy. While increasing attention has been paid to "brain drain" at the state level, this study points to the wisdom of viewing the migration question as a whole, and paying attention to the need to attract bright students from elsewhere to offset the inevitable loss of some homegrown students.

# Who Will Stay and Who Will Leave?

## Executive summary

*WhoWill Stay andWhoWill Leave* had its genesis in discussions that took place among members of the Southern Technology Council (STC), an advisory body to Southern Growth Policies Board. The STC is responsible for strengthening the Southern economy through technology-driven economic development strategies.

Of particular interest to STC members is the reality that seven Southern states rank in the bottom 10 of all states in the percentage of the civilian workforce with a recent bachelor's degree in science and engineering*, and nine Southern states rank below average in the percentage of the civilian workforce with a recent master's degree in science and engineering. Also significantly, those Southern states generally recognized as having the strongest, most dynamic economies (e.g., North Carolina, Virginia, Georgia) rank far above average in one or both categories. Clearly, the factors involved in a graduate's decision to stay or leave the home state are of more than passing concern to policymakers. Though this study is a snapshot, looking at graduates one to three years after they after they left college, we believe that time is a critical period when young professionals either establish their roots in a state or break their roots with their home states.

This study was preceded by a 1998 STC report, *Where Have All the Students Gone?* That report highlighted the role of science and engineering graduates in the economy, documented the disparities that exist across state lines in attracting and retaining such talent, and demonstrated relationships between retention and a variety of factors. The current study moves that analysis down to the individual graduate level in searching for insight on how graduates decide where they will live and work.

Like its predecessor report, this study is based upon the National Science Foundation's National Survey of Recent College Graduates and is supported by a grant from the National Science Foundation.

* From the U.S. Department of Commerce's Office of Technology Policy, *The Dynamics of Technology-based Economic Development: State Science & Technology Indicators*, June 2000

# INTRODUCTION

## BACKGROUND

Over the last five years, the term "New Economy" has become an increasingly frequent catch phrase for the massive changes that are occurring in the world economic environment. To adequately summarize the vast amount of current scholarly and popular commentary about the New Economy, at least in the space we have here, would be an impossible task. Nonetheless, we would make the following summary observations:[1]

- Products in the New Economy tend to have a high amount of knowledge content, often traceable to advances in science and technology. In one sense, the New Economy tends to be "weightless" in that it often involves high-value products and services that have limited physical scope but immense underlying ideas and innovation.

- The New Economy is global in nature, and that globalization has been enabled by rapid advances in transportation, telecommunications, reduction of trade barriers, and electronic commerce via the Internet. Virtual organizations and partnerships that cut across national boundaries are relatively common and increasingly competitive.

- The New Economy is significantly fueled by entrepreneurial enterprises and people. Small, fast-growing firms can exploit new knowledge and technology more effectively, and get to market faster. This new entrepreneurial emphasis has been accompanied by a rejuvenated venture capital industry as well as other novel approaches to early stage capitalization.

- At bottom, the New Economy grows and expands only to the extent that it can find highly skilled people, particularly those who are educated and experienced in the new technologies and business practices. These knowledge workers are in tremendous demand throughout the world, and as a result are highly mobile.

Three years ago the Southern Technology Council conducted a groundbreaking national study on interstate migration of recent science and engineering graduates from colleges and universities. This "brain drain" study accomplished several purposes:

- It highlighted the fact that succeeding in the knowledge-based New Economy is heavily dependent upon firms (and states) being able to retain and attract the best and the brightest in key disciplines. While particularly acute in information technology, the issue of human resources is near the top of firms concerns.

- It documented for the first time the huge disparities across states in the extent to which they are able to attract and retain science and engineering talent. Some states retain the vast majority of their graduates as well as attracting people from other states; other states are net exporters of their most talented young people.

- On the basis of state-level predictive analyses, we were able to demonstrate relationships between retention and various unchangeable geographic givens (e.g., state size, border perme-

## Introduction

ability), plus other factors that might be directly or indirectly altered by policy actions (e.g., technology wages and the fraction of high school graduates who stay in-state to attend college). Turning to factors influencing net migration (essentially attracting talent from other states, or "brain suck"), there were interesting relationships between state higher education tuition levels and net migration (the lower the better), as well as the continuing importance of geography.

Missing from this initial study was an analysis of various individual factors that might influence the decision to stay after graduation and work in-state (e.g., gender, grades, major), as well as an examination of institutional factors that might influence migration choices of graduating students (e.g., type of institution, tuition, private vs. public status). The latter would seem to be quite changeable with various policies, funding, and program innovations.

## Human resources and the New Economy

Since the publication of the first STC study in this area, several trends have emerged in the private and public sectors.[2] For one, in high-growth, technology-based industries, the issue of human resources has become a primary concern. Moreover, the shortages are being felt at all levels, from pre-baccalaureate technician to Ph.D.-level designer of expert systems. In the hottest technology sectors (e.g., information technology and biotechnology) signing bonuses are increasingly being offered, and equity participation has become a useful recruiting tool for start-ups.

In parallel, states have become more aggressive in crafting public policies and programs designed to retain their most talented individuals. Several have launched tuition scholarship programs more-or-less patterned after Georgia's Hope Scholarship Program. Some of these (e.g., Maryland) target certain majors and disciplines, and some have included a requirement that students work in state after graduation, or the scholarship becomes a loan. For the most part, these programs are either too new, or not subjected to rigorous quantitative evaluation, to understand if or why they work.

### What do we know? Research on retention of scientists and engineers

In spite of the fact that there is a long and rich tradition of multidisciplinary research on migration behavior and patterns, this literature has severe limitations given our interests. First, only a portion of the migration literature deals with migration within national boundaries, including interstate migration.[3] As one would imagine, a small portion of this literature examines college students and graduates.[4] Finally, only a fraction of these focus specifically on the graduates who happen to possess the technical and scientific talent in such high demand in the New Economy.

At the same time, the relevant research literature has its own limitations.[5] First, many studies pre-date the current technology-driven economic boom. More recent studies focused on specific subpopulations such as chemical engineers or foreign students or doctoral recipients, or examined a small number of relevant individual or geographic variables, but not both. Aside from the STC study, many of the variables examined did not lend themselves to policy intervention. Finally, most of the studies were based on relatively small non-probability samples that seriously undermine the confidence one could place in the generalizability of their findings.

In spite of these limitations, collectively this literature demonstrates that migration of scientists and engineers is a complex phenomenon, which is probably influenced by a variety of individual and other factors.

## What do we need to know?

As suggested above, what we know about the factors influencing the migration behavior of graduating students is either limited (e.g., few variables, based on non-representative populations), incapable of being acted upon (e.g., permeable borders), or obvious (e.g., pay more). The most interesting and actionable variables uncovered thus far are those of tuition level – seemingly affecting in-migration – and the importance of keeping high school graduates tracked into state-based colleges ("stayers"). The latter could hypothetically be affected by some of the scholarship programs mentioned above; the former would seem to be fertile ground for institutional and state policy experimentation regarding tuition pricing.

There are a variety of issues we would like to understand better and that might have implications for policy. These include: who is most and least likely to be retained; whether the type of higher education institution students graduate from affects retention; whether specific experiences such as cooperative education with local firms influence graduates' retention; at what point do graduates make decisions that begin casting their fate in one direction or another; which factors (e.g., opportunities, security, familial ties) have the strongest influence on a graduate's decision. However, answering all of these questions with a fair degree of certainty would require conducting a large scale and expensive nationally representative survey. Unfortunately, this was not feasible. However, we realized that we could answer many of these questions, as we did in our previous study, by mining national databases.

The following is a list of the types of variables and the issues considered in the study. Some were selected based on previous research, while others were chosen because of their obvious policy relevance. Issues related to variables not contained in the databases we obtained will have to wait for future research.

## Individual factors

Identifying characteristics of the individuals who are the most/least likely to be retained might help states understand precursors to retention and might help states target retention programs. The following seem relevant based on existing research studies and obvious policy considerations:

**Demographics**. Several studies, mostly flawed in ways discussed above, nonetheless point to several demographic variables that might influence the decision to migrate. These include variables such as age, sex, race, and marital status.

**Social/economic variables**. Community "embeddedness," or the density of local family and friendship ties, has been suggested as working against a decision to move. So has income, financial obligations and professional sophistication.

**Academic background**. It has been hypothesized that some academic majors or individuals with advanced degrees may be more inclined to migrate than others, as well as individuals with higher grades and academic honors.

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### INSTITUTIONAL FACTORS

Colleges and universities themselves may act as magnets for students who are more or less likely to be retained or might exert a strong influence on the post-graduation choices of their students. Therefore, characteristics of the institutions from which students graduate will be examined. Relevant variables include: public vs. private, size of institution, tuition level, extent of post-graduate training, and research emphasis at the institution.

### STATE FACTORS

As our previous study demonstrated, state geographic, economic, and policy factors appear to affect migration behavior. However, it is important to note that variables that predict at one level of analysis (e.g., state) may or may not be useful predictors at another level (e.g., individual) or may be redundant with other predictors.[6] As a consequence, we re-evaluate the variables that were found to be significant predictors in our previous study and supplement these with additional variables that tap into New Economy and quality of life dimensions.

### OBJECTIVES OF THE STUDY

The objectives of this study were the following: (1) to identify predictors of student migration behavior, at both the B.S. and M.S. levels in science and engineering; (2) to pay particular attention to those explanatory factors that seem most "actionable" in terms of institution or state policies and practices; (3) to determine if major predictors of student migration behavior uncovered in the earlier STC study hold true; and (4) to suggest implications and action recommendations deriving from the results.

In the next section we will briefly describe the overall research approach, as well as more detailed methods and procedures. This will be followed by a presentation on findings and results and finally a section on implications and recommendations.

# METHODS AND APPROACH

## GENERAL APPROACH

While sophisticated statistical techniques were employed in the project, the basic research approach was straightforward. That is, to identify those factors (variables) that had the strongest relationship with whether graduating B.S. and M.S. students in engineering and the sciences remained in their home state to work. Predictor variables encompassed either individual characteristics, institutional characteristics (of the university the students attended) or state characteristics.

## NATIONAL SURVEY OF RECENT COLLEGE GRADUATES

The National Science Foundation's National Survey of Recent College Graduates (NSRCG) is a national probability survey of bachelor's and master's science and engineering degree recipients.[7] It is designed to provide data on demographic, educational, employment, and other work-related information on recent degree recipients entering the science and engineering labor market and on their current status. We used the most recent NSRCG database available, which included students who received their degrees between July 1, 1994 and June 30, 1996. These former students were interviewed between May and November 1997 about their status as of the target week, April 15, 1997. Thus, the time between graduation and employment status ranged from one year nine months to two years 10 months.

The NSRCG database was made available through the auspices of the National Science Foundation, which also sponsored the project. Access to NSRCG was critical to our ability to achieve the study objectives. First, NSRCG included information on where (which state) a student went to high school and college and where s/he was currently employed. This information allowed us to create retention measures for each student. (See "Outcome Variables" below). In addition, NSRCG included a large number of other variables that described graduates' education, demographics, and employment. Some of these coincided with questions we wanted to address in this study and were used as individual-level predictors. Finally, the fact that NSRCG is a relatively large national probability sample provides us some degree of statistical confidence that our findings should generalize to the national population of science and engineering graduates at the time these data were collected.

## STUDY SAMPLE

The sampling of institutions and graduates for the NSRCG was conducted by Westat, Inc. A two-stage sampling procedure was used. During the first stage, institutions were sampled. During the second stage, individuals within those institutions were sampled.[8]

In the first stage, educational institutions were sampled with a probability-proportional-to-size. Specifically, 102 large institutions offering bachelor's and master's degrees in science and engineering, which train the vast majority of science and engineering graduates, were included. A sub-sample of 73 smaller institutions was also included (total institutions = 175). Most of these institutions were sam-

## METHODS AND APPROACH

pled based on size, and/or the presence of relatively rare major specialties. Finally, a number of smaller institutions with a high proportion of Hispanics, African-Americans and other minorities were oversampled. (It should be noted that the NSRCG does not include doctoral graduates. It would be inappropriate to generalize our findings to that population).

In the second stage, individual degree recipients within these institutions were sampled. Individuals were selected based on a formula that included the size of their institution, the level of degree they received, the year they received their degree, and their respective field of study. This sample included 14,057 individuals (but 1,032 were found to be ineligible). The final respondent sample, which included 10,057 individuals, was refined to adjust for any unequal selection probabilities and nonresponse rates; the procedure adjusted for institutions, academic specialties or disciplines and groups that were over- or under-sampled. These weighted variables were used in all of the analyses reported below

Since we were interested in retention of graduates in a given state's labor force, we also limited our analyses to respondents who were employed during the target week in 1997.[9] A small number of additional respondents were excluded because they did not meet the selection criteria.[10] This resulted in a final sample of 7,741.[11] Some analyses were performed only for U.S. citizens; this sample numbered 6,963.

## DATA COLLECTION

Data collection and processing for the NSRCG database was conducted by Westat, Inc. and involved a complex survey instrument administered via phone interviews and mailed questionnaires. Sampled graduates were located through a variety of information sources including school registrars, change of address services, referrals, and alumni offices. A computerized telephone reference service providing numbers based on name and address information was also used.

The survey instrument itself was organized into four parts: education; employment status; other work-related information; and background information. Each section of the survey involved a number of specific questions organized in branching format, and an individual participant could potentially supply information on over 200 questions. Most questions were either forced choice or fill-in-the-blank requests for information. We used 20 of these variables in our analyses.

To obtain a maximum response rate, no limit was imposed on the number of contact attempts interviewers could make. Messages were left on answering machines for difficult-to-reach respondents, asking them to call a toll-free number. Hard copies of the survey were also sent to hard-to-reach-respondents.

Institutional and state data were obtained from other sources. Institutional data were obtained from the *Institutional Characteristics 1997-98 Survey*. [12] Data were available for 4,025 institutions, including all of the institutions sampled in the NSRCG. State data were obtained from a variety of well-established archival sources.

## Measures

Variables used in the study were classified as outcome variables or predictor variables. The outcome variables were our retention measures. Predictor variables were used to explain the outcome variables and were further classified based on their level-of-analysis, that is, whether the variable described an *individual*, an *institution* (that the individual attended) or a state (that the individual resided in).

## Outcome variables: retention by home state

The logic and methodology for devising measures of retention were developed in our earlier study, Where have all the students gone? Retention can be evaluated based on a comparison of the state an individual lived in when they completed a specific educational milestone and the state they were employed in during the target week for the NSRCG. In other words, from a state's perspective retention is a reflection of the extent to which a state captures the economic potential of individuals who have been educated within its borders, often at taxpayer expense.

Based on this logic, two retention measures were created: *Retention/Most Recent Degree* and *Retention/High School*. For *Retention/Most Recent Degree*, graduates who were employed in the same state they received their most recent degree from were coded retained; a graduate who was employed in any other state was coded not retained. For *Retention/High School*, graduates who were employed in the same state they received their high school diploma from were coded "retained;" a graduate who was employed in any other state was coded "not retained."[13]

An overview of the 50 variables examined in the study is presented in Table 1(next page). These are organized by broad conceptual category so as to be more understandable to the reader. The sources for these variables, and other computational details, are described in the endnotes.

## Table 1

| Variable | Definition | Data/ Category Type |
|---|---|---|
| **Individual Level:** | | |
| Age | Respondent's age category | Continuous (5 year groupings) |
| Annual Salary | Annual salary | Continuous ($10,000 units) |
| Citizen (US Citizen Reference) | US Citizenship | Temporary Resident, Permanent Resident (US Citizen reference) |
| Embedded | Composite index 0-3 (Married, Spouse Working, Children in the home) | Composite index 0-3 indicating degree of community linkage |
| Financial Assistance | Source of Financial Assistance | Repayable loans, Non-repayable grants, Earned from Employment, Employer Assistance, Other |
| Gender | Self identified gender | Male, Female |
| GPA | Undergraduate Grade-point-average | Grade-point-average (4.0 scale, .5 units) |
| Level of Degree | Degree Type | Bachelor's, Master's |
| Major (Engineering Reference) | College Major | Computer/ Math, Life Sc., Physical Sc., Social Sc., (Engineer reference) |
| Number of Degrees | Number of degrees earned (Bachelor's or higher) | Continuous |
| Professional Sophistication | Attend Professional Conference or Membership in Professional Org | Neither Conference nor Member, Either Conference or Member, Both Conference & Member |
| Race (White Reference) | Self reported race | Black, Asian, Hispanic, Native American (white reference) |
| Stayer | Stay in-state for college | Dichotomous (stay vs. leave) |
| **Institutional Level:** | | |
| Average Tuition | Undergraduate tuition, (in-state/ out-state) | Continuous ($1,000 unit) |
| Carnegie Classification | Carnegie Classification Code | Continuous (Range 9= Research I Univ to 0=Associate of Arts College) |
| Degree of Urbanization | Degree of Urbanization | Continuous (Range 1=Large City to 7=Rural) |
| Institution Affiliation (Public Non-Landgrant Reference) | Affiliation of Institution | Historically Black; Private Independent Non-Religious; Private Religious; (Public Non-Landgrant reference) |
| Institution Enrollment | Fall enrollment count | Continuous (1,000 unit) |

# Table 1 (cont.)

| VARIABLE | DEFINITION | DATA/ CATEGORY TYPE |
|---|---|---|
| **State Level:** | | |
| Average technology wage | Average wage in the high-tech industry 1995 | Continuous (1,000 unit) |
| Digital Economy | Composite Index of (On-line population; Commercial Internet Domain Names; and Digital Government) -- as reported in New Economy Report | Continuous |
| Economic Dynamism | Composite Index of (Gazelle Jobs; Job Churning; and Initial Public Offering)-- as reported in New Economy Report | Continuous |
| Fed fund def per capita | Federal Funds and grants (Dollars divided by population) | Continuous |
| Fed fund per capita | Federal Funds and grants (Dollars divided by Gross State Product) | Continuous |
| Globalization | Composite Index of (Export Focus of Manufacturing; and Foreign Direct Investment) | Continuous |
| Higher educ fund per capita | Higher education current-fund | Continuous |
| Gross State Product per capita | Gross state product, 1996 (Dollars divided by population) | Continuous |
| Income per capita | Average personal income per capita, 1997 | Continuous ($10,000 units) |
| Innov Capacity | Composite Index of (High Tech Jobs; S&E; Patents; Industry Investments in R&D; and Venture Capital) | Continuous |
| Knowledge Jobs | Composite Index of (Office Jobs; Managerial, Professional, and Technical Jobs; and Workforce Education) | Continuous |
| Patents per residents per capita | Patents issued to state residents, 1997 divided by population | Continuous |
| Population | Population, 1997 | Continuous (millions) |
| Quality of Life- Climate | Mildness, Brightness, Stability are rated according to their influence on climate | Continuous |
| Quality of Life- Cost of Living | Factors are weighted according to their relative importance in a typical four-person household's budget | Continuous |
| Quality of Life- Crime | Violent crime and crime against property are evaluated. | Continuous |
| Quality of Life- Education | Factors are weighted progressively heavier, and no distinction is made between publicly and privately run institutions | Continuous |
| Quality of Life- Health Care | Factors influencing the easy of Health Care services are evaluated. | Continuous |
| Quality of Life- Jobs | Rate of current increase in jobs and number of jobs | Continuous |
| Quality of Life- Recreation | Recreation land, golf, movies and good food | Continuous |
| Quality of Life- The Arts | Bigness, Reading popularity, and Museum popularity | Continuous |
| Quality of Life- Transportation | Each factor is weighted differently-- connectivity is 60% of the final score, commute is 30%, and centrality is 10%. The sum of these weighted scores for each metro is then normalized such that the 50 $^{th}$ percentile point is the average for all metro areas. | Continuous |
| R&D Academic per capita | Academic R&D, 1996 (millions) | Continuous |
| R&D Industry per capita | Industry R&D, 1995 (millions) | Continuous |
| Total R&D Performance per capita | Total R&D performance, 1995 (thousands) divided by population | Continuous |
| Work out-of-state | Percent of state residents employed in another state | Continuous |

## METHODS AND APPROACH

### PREDICTOR VARIABLES

As described earlier, predictor variables were grouped by levels-of-analysis: individual-level, institutional-level, and state-level.

#### Individual-level predictors

Individual-level predictors were grouped into three domains: demographics, educational variables, and social/economic variables:

#### Demographics

This set of predictors included a number of fairly typical demographic measures including: *gender, citizenship* (U.S., permanent resident, temporary resident), *race* (white, black, Asian, Native American), *age* and *stayer*, a variable reflecting whether an individual attended college (for their most recent degree) in the same state that they received their high school diploma.

Stayer is really two distinct variables. Since graduates' retentions are evaluated based on where they completed their educational milestone (high school diploma or most recent degree), the interpretation of this variable will differ for each outcome variable. For *Retention/High School*, this variable identifies *stayers* (attended college in the same state as they attended high school) and *leavers* (attended college in a different state than they attended high school). For *Retention/Most Recent Degree*, this variable identifies *stayers* (attended college in the same state as they received their high school diploma) and *arrivers* (attended high school in another state but attended college in the focal state). To avoid confusion we will refer to this variable as *stayer/leaver* for *Retention/High School* and *stayer/arriver* for *Retention/Most Recent Degree*. We also believe that this nomenclature also labels radically different kinds of experiences. One can assume that the phenomenology of coming fresh into a new state to attend college, and then deciding whether to work there or not, is quite different than that of the student who has spent most of their life in the same state.

#### Educational factors

This set of variables describes an individual's educational achievement and/or area of specialization and included: *major field* (engineering, computer and mathematics, life science, physical science or social science), *grade point average* (undergraduate), *degree* (bachelor's/master's), and *number of degrees*.

#### Social/economic

This set of variables attempted to measure certain aspects of an individual's social and/or economic status. The variables as measured tended to be fairly crude proxies for social and/or economic status and included: *embeddedness*, a composite index that reflects the extent to which an individual is socially embedded by virtue of being married, having children and having a working spouse; *professionalism*, another composite index that reflects membership in professional organizations and participation in professional conferences; and *financial aid* (source of tuition financial aid: employer, loans, grants, earnings, other).

### INSTITUTIONAL FACTORS

Institutional factors were descriptive of the higher education institution the graduate received their most recent degree from. As described earlier, data were obtained from the *Institutional*

*Characteristics Survey for 1997-98*. Institutional variables included the following: *affiliation* (private independent, private religious affiliation, pubic land grant, public other); *Carnegie Classification*, a measure of how research intensive an institution is; *faculty size*; *urbanization* (of community university located in); *graduate student enrollment; undergraduate enrollment;* and *tuition charged*.

## STATE FACTORS

State variables were grouped into four categories: state demographics, general economic characteristics, technology-based economic characteristics, and quality of life. Variables that were significant in our previous study were examined.[14] In addition, variables were gleaned from two additional sources recently published: *State of the New Economy*[15] and *Places Rated Almanac*.[16]

### State characteristics

Only one general characteristics variable was used: population.

### General economic characteristics

The following economic characteristics were standardized based on state population: *federal funding for defense, federal funding, gross state product, higher education funding, income*.[17] In addition, composite indexes of *economic dynamism* (based on gazelle jobs, job churning, initial public offerings) and *globalization* (export focus of manufacturing and foreign direct investment) were examined.

### Technology-based economic characteristics

Technology-based economic characteristics (also standardized by state population where appropriate) included: *average technology wage, patents, academic R&D, industry R&D, total R&D performed*. In addition, the following composite indexes were examined: *digital economy* (on-line population, commercial internet domain names, technology in schools, digital government), *innovation capacity* (high technology jobs, scientists and engineers, patents, industry R&D, venture capital) and *knowledge jobs* (office jobs, managerial, professional, and technical jobs, workforce education).

### Quality of life

Research has pointed to quality of life as an important ingredient in the location choices of knowledge workers and technology-based companies.[18] Since we were interested in state-level predictors and quality of life is typically measured at the level of the metropolitan area, we had to develop our own state-level indices.[19] The following quality-of-life subfactors were used: *cost of living, transportation, jobs, higher education, climate, crime, arts, health care, recreation*. For a detailed description of the variables included in each of these measures the reader is referred to *The Places Rated Almanac.*

## STATISTICAL ANALYSIS

The nature of the project placed several constraints on the most appropriate approach to statistical analyses. For one, the primary outcome variable was that of in-state retention on the part of graduated students in engineering and the sciences. As such, retention is a dichotomous, yes-no measure, a fact that forced us to look for statistical tools that would be robust in handling this type of data.

A second constraint was our interest in identifying what combinations of predictor variables were

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most responsible for retention behavior. That is, we wanted to use a multivariate approach to understanding what was associated with retention.

Third, as the discussion above indicates, there were several levels of predictors (e.g., individual, institutional and state) the team wanted to examine concurrently.

In order to accomplish the study objectives, within the constraints imposed by the nature of the data at hand, logistic regression analysis was employed as the primary statistical tool.[20] The mathematical assumptions underlying this approach are consistent with the data available to the study team, the approach is quite robust, and the results are intuitive and understandable by a lay audience. In effect, individual predictor variables and combinations thereof will clearly differentiate former students into those most likely to stay in state to work after graduation versus those who will leave. That is, what are the key positive factors that promote retention versus the risk factors that encourage leaving?

Since we were considering a large number of variables and there is little a priori empirical or theoretical basis for identifying the most likely predictors, we decided to screen our variables empirically. That is, a series of logistic regressions were performed: predictor-to-outcome, multiple variables in a domain-to-outcome, and so on. Only if a variable was statistically significant at one stage (predictor-to-outcome) was it considered at the next step (multiple variables in a domain-to-outcome). This approach helped narrow the field of potential predictors and helped eliminate predictors that were redundant (highly related) with other predictors. Finally, in order to ensure a greater degree of confidence in our findings, given the relatively large sample size, we chose to use a more stringent level of statistical significance, $p<.001$, as compared to the usual $p<.05$.

## ANALYSIS STRATEGY

### Screening predictor variables

As described in the previous section, the statistical analysis encompassed 44 predictor variables that were assembled at the individual (13 variables), institutional (five variables), and state levels (26 variables) of analyses. Preliminary analysis examined simple one-to-one relationships between these predictors and the outcomes. Predictors that were statistically important at this level were then subjected to an analysis where they were grouped with other predictors from the same domain (e.g, demographics) and level (e.g., individual, institutional or state characteristics) and re-examined. As a result of this procedure, 23 variables were retained for the final full model statistical analyses.

# Results

This section will describe three types of results deriving from our analyses. One will acquaint the reader with some broad descriptive statistics about the scope of the retention and migration phenomena. The second section will present in considerable detail the final predictive result of our analyses that, as discussed above, was the main focus of the study. The final section will present some supplemental analyses we undertook to clarify some of our results as well as a summary of the variables that predicted retention.

## Understanding retention

The scope of interstate commerce of the best and brightest engineering and science minds is enormous. Of those individuals who obtain their high school degree in a given state, 43.2 percent, almost one out-of-every two science and engineering graduates, will take a job in another state when they complete their college education. However, as our previous STC analyses demonstrate, retention can vary tremendously across states. For example, the highest performing states retained an estimated 81 percent while the lowest state retained 18 percent.[21] For those governors, legislators, economic development officials, and educational leaders who were already concerned about brain drain and the New Economy, these figures should be cause for alarm.

Not only are these migration patterns large, but there is some evidence that they are stable over time and cumulative in their impact. That is, if a given state has a relatively high rate of out migration of its graduates without a corresponding in-migration of talent, then over time the human resource assets available for participating in the knowledge economy are likely to become degraded.

For example, based on estimates of the retention of recent college graduates from 25 of the larger states represented in the 1993 and 1997 NSRCG,[22] the general pattern of performance holds over this period for most states. In fact, a computed correlation coefficient[23] between 1993 and 1997 scores, which probably provides a conservative estimate,[24] was very high (r=.77) and statistically significant. Brain drain seems to be a fairly stable phenomenon that may be difficult to turn around.

## Predicting state retention of recent college graduates — graduates who received their high school degree in that state

Table 2 presents predictive results for Retention/High School. Eight of the 12 variables examined in these analyses were statistically significant predictors: *stayer/leaver, grade point average, major, salary, research intensiveness* (Carnegie Classification), *population, economic dynamism, and quality of life – health care*. It is important to realize that these variables are significant based on our multivariate analysis. *That is, they are significant after controlling for all the other variables in the analysis*. Together these variables reduce the error in the predicting the outcome measure by 30 percent. By almost any standard, this is a very large effect.

## RESULTS

### TABLE 2

**Summary of Overall Multivariate Logistic Relationships with Retention**

| High School (n=6,963) | Multivariate Odds ratio |
|---|---|
| **Individual Level** | |
| **Stayer** | 10.22* |
| **Race (White Reference)** | |
| Hispanic vs. White | 1.26 |
| Black vs. White | 1.03 |
| Asian vs. White | 1.36 |
| Native American vs. White | 1.20 |
| **GPA** | .870* |
| **Major (Engineering Reference)** | * |
| Computer & Math vs. Engineering | 1.42 |
| Life Sciences vs. Engineering | 1.60 |
| Physical Sciences vs. Engineering | 1.10 |
| Social Science vs. Engineering | 1.74 |
| **Salary (10k)** | .922* |
| **Institutional Level** | |
| **Carnegie Classification** | .960* |
| **Average Tuition** | 1.00 |
| **Institution Affiliation (Public Reference)** | |
| Public Land grant vs. Public | 0.78 |
| Private Independent vs. Public | 1.01 |
| Private Religious vs. Public | 1.30 |
| Historically Black vs. Public | 0.74 |
| **State Level** | |
| **Population** | 1.03* |
| **Economic Dynamism** | 0.91* |
| **Digital Economy** | 0.97 |
| **Health Care** | 1.01* |

p<.001 Analog $R^2$ = 30.15 percent

In order to interpret these results one needs to understand two indices used in logistic regression: odds ratio and analog $R^2$. An odds ratio is a standard statistic that indicates the size and direction of the effect of an individual predictor. Odds ratio can be interpreted relative to 1. An odds ratio of 1 would indicate the predictor has no effect on the outcome. An odds ratio above 1 indicates a unit change in the predictor increases the odds of retention (multiplicatively[1] ) by that amount. Thus, an odds ratio of 2 means every unit increase in the predictor increases the odds of retention two times. An odds ratio below 1 indicates a unit change in the predictor decreases the odds of retention (multiplicatively) by that amount. An odds ratio of .75 means a unit increase in the predictor decreases odds of retention by 25 percent.[1]

On the other hand, analog $R^2$ is a summary statistic that reflects the aggregated effect of all the predictors. An analog $R^2$ is a measure of error reduction. An analog $R^2$ of .25 means that collectively the predictors improves our prediction (by reducing our errors) 25 percent.

## Results

### Individual-level predictors

**Stayer / leaver.** The *stayer / leaver* variable (whether an individual stayed in-state to attend college or left to attend college elsewhere) was an extraordinarily powerful predictor of retention. The odds that a person would be working in the same state they attended high school in were increased over 10-fold (1,022 percent) if that individual remained in state to attend college. In effect, *stayers* stay. We attempt to shed some light on what factors are associated with this phenomenon in "Additional Analyses," below.

**Grade point average** (GPA). Increases in undergraduate GPA reduced the odds of retention. Every half-point GPA-score (e.g., GPA of 2.5 to a GPA of 3.0) reduced the odds of that an individual would end up working in the state that they received their high school degree in by 13 percent. In other words, the best and brightest, as judged by GPA, are more likely to find employment out-of-state.

**Major.** The odds ratios regarding academic major in Table 2 are all comparisons to engineering.[25] At the risk of oversimplification, our results demonstrate that engineering and physical science majors are significantly less likely to be retained than all other majors (life science, math / computer science, or social science).[26] For example, compared to an engineering major (which has the lowest retention),[27] the odds of retaining a social science major are 70 percent higher, the odds of retaining a life science major are 60 percent higher and the odds of retaining a computer / math major are 40 percent higher. A post hoc comparison of math vs. computer science majors demonstrated that computer science majors were significantly lower on retention and, thus, more like engineers and physical scientists. All things being equal, engineers and physical science (and computer science) majors, with their highly sought after technical skills, are less likely than other majors to be working in the state they received their high school diploma.

**Salary.** Higher salaries (what an individual is currently earning) reduce the odds an individual will be retained in a state's job market. Every $10,000 increase in salary decreases the odds roughly 8 percent that a person will be working in the state where they received their high school degree.

### Institutional-level predictors

**Research-intensive institution.** If an individual received a degree from a more research-intensive institution, as measured by Carnegie Classification, they were less likely to end up working in the state where they received their high school degree. For every increase in level of research intensity (e.g., from a Research II to a Research I or from a Doctoral University I to a Research II) the odds decrease a fairly modest (but statistically significant) 4 percent the person will be working in the state they received their high school degree.

### State-level predictors

**Population.** The bigger the state where the high school diploma was received, the more likely a graduate is to be retained. Every increase in state population of 1 million increases the odds of retention roughly 3 percent. For instance, in a state with a population of 5 million, the odds that a graduate would remain in the state to work would be 6 percent higher than in a state with a population of 3 million.

## Results

**Economic dynamism.** Increases in economic dynamism, an index comprised of measures of gazelle companies, job churning, and value of companies' IPOs, decrease the odds that an individual will be retained.[28] A unit increase in economic dynamism (scale ranges from about 3 to 11) decreases the odds of retention by roughly 9 percent that a graduate will be working in that state after graduation from college. This finding is hard to interpret. It suggests that science and engineering graduates will leave a highly entrepreneurial state economy. An analysis of rankings from *Where have all the students gone?* reveals that states high on economic dynamism tend to be low on retention, but high on net migration (retention plus in-migration from other states). This suggests that states that experience a lot of pressure from in-migration may lose their appeal or become too competitive for some local graduates.

**Quality of life - health care**. Increases in *quality of life – health care* increase the odds of retention. A unit increase in *quality of life – health care* increases the odds of retention roughly 1 percent.

In summary, staying in state to attend college, majoring in something other than engineering or physical sciences, attending high school in a more populous state and with higher health quality of life increases the odds of retention. While getting a higher undergraduate GPA, earning a higher salary, attending a research-intensive university, and attending high school in a state with high economic dynamism decreases the odds of retention.

## Predicting state retention of recent college graduates — graduates who received their most recent degree in that state

Table 3 (following page) presents predictive results for Retention/Most Recent Degree. Twelve of the 19 variables examined in these analyses were statistically significant predictors: *stayer/arriver*, *age*, *citizenship*, *major*, *salary*, *degree of urbanization*, *research intensiveness* (Carnegie Classification), *institutional affiliation*, *enrollment*, *population*, *work-out-of-state*, and *economic dynamism*. While still large, compared to the results just reported, this analysis produced a less powerful and efficient solution. Together these 12 variables reduce the error in predicting the outcome measure by 18 percent.

## Individual-level predictors

**Stayer/arriver**. The *stayer/arriver* variable (whether an individual stayed in state to attend college or arrived in a state for college after having received a high school diploma elsewhere) was a very powerful predictor but not nearly as powerful as the *stayer/leaver* variable in the previous section. The odds that a person would be working in the same state as they received their most recent degree from increased over four-fold (423 percent) if that individual had also gone to high school in that state. In other words, home-grown college graduates are more likely to be retained than college graduates who received their high school education (and presumably have ties) elsewhere.

**Citizenship.** A second statistically powerful and policy relevant set of predictors concerned citizenship status.[29] To summarize, non-U.S. nationals are more likely than U.S. citizens to stay and work in the state where they receive their most recent degree. The qualification for this finding is that it only per-

## TABLE 3

| Most Recent Degree (7,741) | Multivariate Odds ratio |
|---|---|
| **Individual Level** | |
| **Age** | 1.08* |
| **Stayer** | 4.22* |
| **Race (White Reference)** | |
| Hispanic vs. White | 1.33 |
| Black vs. White | 1.04 |
| Asian vs. White | 0.97 |
| Native American vs. White | 1.40 |
| **Citizen (US Citizen Reference)** | * |
| Permanent Resident vs. US Citizen | 1.98 |
| Temporary Resident vs. US Citizen | 1.44 |
| **Major (Engineering Reference)** | * |
| Computer & Math vs. Engineering | 1.26 |
| Life Sciences vs. Engineering | 1.06 |
| Physical Sciences vs. Engineering | 1.02 |
| Social Science vs. Engineering | 1.29 |
| **Salary (10k)** | 0.85* |
| **Embedded** | 1.05 |
| **Institution Level** | |
| **Degree of Urbanization** | 1.12* |
| **Carnegie Classification** | 0.94* |
| **Enrollment Total** | 1.01* |
| **Average Tuition** | 0.98 |
| **Institution Affiliation (Public Other Reference)** | * |
| Public Land grant vs. Public Other | 0.64 |
| Private Independent vs. Public Other | 0.99 |
| Private Religious vs. Public Other | 0.84 |
| Historically Black vs. Public Other | 0.49 |
| **State Level** | |
| **Population** | 1.03* |
| **Work out-of-state** | 0.95* |
| **Income Per Capita** | 0.98 |
| **Economic Dynamism** | 0.95* |
| **Arts** | 0.99 |
| **Crime** | 1.00 |
| **Transportation** | 1.01 |

* p<.001 Analog $R^2$ = 18.24 percent

## Results

tains to noncitizens who are working somewhere in the U.S. after graduation (as opposed to those who have returned to their home country).[30, 31] That notwithstanding, the magnitude of the effect of this variable is considerable. Compared to a U.S. citizen, the odds of a permanent resident staying on to work where he or she received their degree is 98 percent higher. Similarly, the odds of a temporary resident staying on in the state where they matriculated are 44 percent higher than for U.S. citizens. We attempt to confirm the validity of these effects in our "Additional Analyses" section below.

**Major.** In essence, major has roughly the same effect here as it did for Retention/High School. Engineering and physical science majors are significantly less likely to be retained than computer/math and social science majors (but not compared to life science). The odds of retaining a computer/math major are 26 percent higher and the odds of retaining a social scientist are 29 percent higher than an engineering major (which had the lowest retention). A post hoc comparison of math vs. computer science majors demonstrated that computer science majors were significantly lower on retention and, thus, more like engineers and physical scientists.

**Age.** Older students tend to have higher odds of being retained in the state where they received their most recent degree than younger students. Every five-year increase in age increases the odds of retention about 8 percent.

**Salary.** Consistent with our previous results, higher salaries reduce the odds of retention. Every $10,000 increase in salary decreases the odd approximately 15 percent that a person will be working in the state where they received their most recent degree.

## Institutional-level predictors

**Research-intensive institution.** Consistent with our previous results, individuals who receive their degree from a more research-intensive institution are less likely to be retained. For each one-level increase in research intensity (range from 1-8) the odds decrease 6 percent the person will be working in the state they received their most recent degree.

**Institutional affiliation.** Institutional affiliation, or the type of institution an individual attends (e.g., public, private), affects the odds of retention. In a nutshell, the odds of retention are higher for students who attend *public other*, *private independent*, *private religious* institutions than for *public land grant* and *historically black institutions*. For instance, receiving a degree from a public land grant school decreased the odds 36 percent that one would be retained compared to attending public other institutions. Of even greater magnitude, receiving a degree from a historically black institution decreases the odds 51 percent compared to other public institutions. One interpretation of these findings (untestable with the current database) is that land grant and HBCU institutions may mount placement services that are more national in scope, or at least attract a larger number of national companies. Given the relative shortage of minority scientists and engineers, that interpretation seems to fit with HBCUs.

**Degree of urbanization**. The more urbanized the community is that students live in when they receive their degree, the higher the odds they will be retained. Every unit increase in urbanization (scaled from 1, large city, to 7, rural) increases the odds of retention by approximately 12 percent.

**Enrollment.** Larger enrollment universities increase retention (1 percent for every 1,000-student increase).

## STATE-LEVEL PREDICTORS

**Population**. Consistent with our earlier results, the bigger state that graduates received their most recent degrees from, the more likely they are to be retained. Every 1 million increase in state population increases the odds of retention roughly 3 percent.

**Economic dynamism**. Increases in economic dynamism decrease the odds that an individual will be retained. A unit increase in economic dynamism decreases the odds of retention by roughly 5 percent that they will work in that state after graduation from college.

In summary, staying in state to attend college, being a foreign student majoring in something other than engineering or physical sciences, being older, attending a university in a more urban environment or with a larger enrollment, and attending college in a bigger state increase the odds of retention. While earning a higher salary, attending a research intensive university or a university with a higher tuition or a land grant university, and attending high school in a state with high economic dynamism decrease the odds of retention.

# Additional analyses

Some additional analyses were performed to clarify some of our findings and/or to evaluate related questions.

## Getting a better understanding of stayers

By far the largest effect observed in our study (for both outcome variables) was the influence of *stayer*. In order to make our logistic regression-based results a little more accessible to the lay reader, we decided to present retention data in percentages for stayers, leavers, and arrivers. While this presentation is not exactly equivalent to our multivariate findings, it will make the influence of staying, leaving, and arriving a little clearer. As Table 4 demonstrates, the average state can expect to retain 76 percent of its *stayers* (attend high school and college in same state), 43 percent of its arrivers (attended high school elsewhere but received most recent degree in focal state), and 23 percent of its leavers (attended high school in focal state then left to attend college elsewhere). As our earlier results implied but did not demonstrate, arrivers are intermediate between stayers and leavers in terms of their likelihood of retention. When calculated, the odds ratio for leavers vs. arrivers turns out to be 2.5. That is, arrivers are roughly 2.5 times more likely to be retained than leavers.

### Table 4

**Average state retention of graduates**

| Stayers | Arrivers | Leavers |
|---|---|---|
| 76% | 43% | 23% |

In summary, while the average state will lose most of their leavers, they usually compensate for some of that loss because they will retain nearly half of their arrivers. As a consequence, all other things being equal, the relative size of a state's leaver and arriver cohorts should influence downstream retention. States that have lots of students leaving to attend college in other states and few students arriving from elsewhere to attend college in state will typically pay a price down the road in terms of a smaller science and engineering labor force.

To further understand this phenomenon, additional analyses were conducted to shed some light on who stays and who leaves. On a somewhat discouraging note, a cluster of best and brightest variables predicted leaving: *GPA, M.S degree, financial aid – scholarship*. That is, those who went on to post higher grade point averages in college, who eventually achieved a M.S., who received a college scholarship, were less likely to stay home for college. Individuals who reported working to pay their tuition were more likely to stay.[32] These relationships have policy significance that will be explored below.

## What about information technology workers?

Although it was not directly coded in our variables, we were able to create a variable for information technology worker or skills.[33] Despite the wide discussions in policy circles and the popular press on the importance of "information technology workers in the New Economy," we failed to find a relationship in this study. That is, when we substituted this variable for major in our multivariate analysis, it did not have a unique relationship to the outcome variables. This may be a function of a weakness in our predictor variable or an inadequacy in the way the term "IT worker" is defined.

## Are foreign students really more likely to be retained?

In the analyses that evaluated the impact of citizenship, we had to make a decision about how to handle coding for the *stayer/arriver* variable for foreign students. We were confronted with two options: consider this variable missing data and ignore foreign students in our analyses or code virtually all of these students arrivers since they did not attend high school in the U.S., let alone in the state they attended college. We chose the latter option. Since some researchers might disagree with this decision and might believe it biased our findings, we decided to conduct some additional analyses. First, we evaluated the simple bivariate relationship between retention and citizenship. Next, we repeated our multivariate analyses without the *stayer/arriver* variable. These analyses tended to confirm our earlier analyses. Foreign students who were permanent residents were still more likely to be retained. However, foreign students who were temporary residents were either less likely (bivariate) or showed no difference.[34] In our view, these analyses appear to support the more limited conclusion that foreign permanent residents are more likely to be retained than U.S. citizens.

## What did not predict retention?

Not surprisingly, many of the variables we considered promising predictors did not explain retention, at least in our multivariate model. These include: *gender*, *race*, *degree*, *number of degrees*, *embeddedness*, *professionalism*, *financial aid*, *faculty size*, most of our state general economic conditions (except *economic dynamism*), all of our state technology-based economic conditions, and most of our quality-of-life measures (except for *health care*).

Some of these seemed like important and policy relevant variables. For example, gender seemed to be related when examining one-to-one relationships with outcomes (females were more likely to be retained), but it dropped out of later analyses because its predictive contribution was redundant with other predictors. In effect there is no unique contribution of gender to the retention phenomena. Similarly, there were some statistical findings that suggested race and ethnicity might be an important contributing factor; however, when combined with other variables, its unique contribution was redundant with other predictors.

The research team also assumed that a measure of socio-economic status might be a determinant of graduated students' migration decisions. While an admittedly crude index of financial status was statistically important in some of the earlier analyses, this also washed out in the final analyses. However, we think this question is still open and it would be useful if subsequent additions of the NSRCG database examined this more carefully.

As a final area of potential predictive relationships, the findings on relationships between quality of life were inconclusive and discouraging. Only one quality of life indicator (*health care*) entered into the final set of predictors. However, we think this question is still open. We think our method of creating state-level indicators was too blunt an instrument to answer these questions.

In our conclusions, we make some recommendations for how future research might be able to test these questions in a more definitive manner.

# Discussion and policy recommendations

This analysis of student migration that occurs shortly after college graduation (roughly 1.75 years to 2.75 years) began with a large number of potential predictors, and ended up with but a few that were found to be statistically important. As we expected, the current multi-level multivariate analyses of retention paints a different, and we think more complete, picture of the factors that predict retention compared to our earlier single level-of-analysis (state level) study, *Where have all the students gone?* While a number of variables were important in both studies, most notably stayer (and population size, work-out-of-state (percentage)), these findings highlight a number of additional individual and institutional variables that have enlightening policy and practice implications.

In this section, we will dwell on those significant predictors that seemingly have the most profound repercussions on institutional and state policies and practices. In addition, we will make some comments on methodological issues, particularly the usefulness and shortcomings of the NSRCG database.

## Stayers stay

Whether or not a student graduating from high school goes on to college in the same state was by far the most important predictor of where he or she worked after college graduation. However, policy makers probably need to consider three different groups: *stayers* (high school and college in same state), *leavers* (high school in focal state, then college elsewhere), and *arrivers* (high school elsewhere, then college in focal state). *Stayers* are the best bet; the odds of retaining them are 10 and four times greater than *leavers* and *arrivers*, respectively. However, it is also worth noting, the odds of retaining *arrivers* is 2.5 times greater than *leavers*.

### Policy implications

We are a very mobile society and some students are going to decide to leave home to attend college in other states. As a consequence, states need to pay close attention to the relative number of leavers and arrivers. States that attract at least as many college enrollees from other states as they lose will be in a much better position than states that tolerate a one-way (out) traffic in college enrollees.

Regardless, states need to intervene earlier in the educational and vocational choices made by their young people. They can gain significant relative advantage by harvesting talented high school graduates from their state by aggressively encouraging and giving them incentives to stay home for college. As examples, Georgia's Hope Scholarship program, Nevada's Millennium Scholarship plan, and Michigan's Merit Award program have all been structured to provide tuition subsidies for students with above average high school grades and/or high standardized national test scores.

## Target the best and brightest

Our findings appear to confirm the worst fears of some policy makers – out-migration is higher among the best and brightest. Retention/High School negatively related to GPA and leavers tend to have higher GPAs, more scholarship offers, possess more advanced degrees, etc.

## Policy implications

As suggested by our data, some retention programs probably do not go far enough in that they are not highly selective in terms of expectations regarding high school academic performance. States need to exert special effort on their very best and brightest people, such as those who are in the top few percentiles on national competitive exams. Our evidence indicates that many of these students leave their home states after high school and are likely not to return. In effect, academic stars in high school tend not to be *stayers*, nor do they come home for their first job. In response, states could make an effort to more than match any external scholarship offer made to National Merit Scholarship winners from their state, provided that they attend an in-state institution. Similarly, highly competitive scholarship offers could be extended to high school valedictorians. These scholarships could go beyond tuition support, and include room, board, and related expenses. In fact, states could mimic the negotiating behavior of new car dealers, automatically upping the ante 10 percent over any competitive offer. Similarly, states might become nationally competitive in the recruitment of Merit Scholars from other states. Of course, such efforts might be counterproductive if they were paid for by reducing support for need-based scholarships, which allow some students to attend college who otherwise might not.[35]

There is also reason to believe that another ingredient in successfully recruiting talented high school graduates involves the national reputation of in-state colleges and universities.[36] This is particularly important for the academic elite and their parents, who both pay attention to the various ratings and rankings of higher education institutions. They are attracted to institutions that can boast of national standing in those academic disciplines that coincide with long-term career goals. That suggests state-based institutions should build a distinctive culture of excellence that emulates that of the historically elite colleges and universities. Moreover, to the extent that a state wants to feature technology as an important ingredient in its economic development strategy – and to maximize the attraction and retention of talented people as a key tactic – then it needs to focus resources on those science and engineering departments in its colleges and universities that function as a magnet for the best and brightest.

## ARRIVERS STAY

As reported above, *arrivers* from other states tend to stay on in employment in the state where they receive their college degree. Moreover they do so at a rate that is quite a bit higher (43 percent vs. 24 percent) than those *leaver* individuals who are native to a state and then decide to go elsewhere to college after finishing high school. Depending on the quality of this influx, these individuals provide an important vehicle for states to replenish their pool of science and engineering graduates, particularly if those states are beset by a relatively high rate of *leavers*.

## Policy implications

The *arriver* phenomenon has important implications for states, as well as for state-supported academic institutions. In many states, out-of-state enrollees are seen as interlopers who are taking up a place that might be allocated to qualified in-state high school graduates, and who therefore should be subjected to out-of-state tuition fees that are often extraordinarily high. For institutions, this has been a significant source of revenues.

## Discussion and policy recommendations

Our results suggest that this approach should be reconsidered. It may be more in the economic development interest of states to provide vehicles by which out-of-state tuition charges can be relaxed, deferred, or exempted. For example, if a science or engineering student *arriver* remains after graduation to work in a technology-based company, there could be a multi-year tax credit under which all out-of-state fees could be returned. Alternatively, an arriver student could have out-of-state fees waived while still in school if he/she promised to accept an in-state job after graduation. To the extent that such policies would negatively impact institutional revenues, an accompanying policy of institutional reimbursement would be needed.

In addition to accommodating out-of-state *arrivers* who voluntarily enroll, our findings also suggest that states and state-supported institutions should be more aggressive generally in marketing their science and engineering programs in prospective high school graduates in other states. To compete in this larger market, of course, they would have to present an attractive image (and reality) of academic excellence, which would have positive implications for all concerned. Elsewhere in this section we have suggested that more expansive approaches to scholarship aid be considered, particularly regarding elite high school students from other states who are considering science and engineering careers.

## Immigrants stay

Foreign students may play a critical role in the U.S.'s science and engineering workforce. About 12.7 percent of all scientists and engineers are foreign born (26.1 percent of Ph.Ds).[37] A recent report suggests that U.S. economic development will benefit if universities "attract the smartest people from around the world—the true wellspring of the knowledge economy."[38] According to our findings, states would be well advised to heed that message. Foreign students who are permanent residents are more likely to stay where they received their most recent degree than are U.S. citizens. This seems to be a fairly powerful and robust finding, which given the ongoing and often painful discussion about the prominence of foreign students in science and engineering programs, ought to be of interest to academic and lay leaders alike.

### Policy implications

Consistent with the long and vibrant history of newcomers being welcomed and assimilated into American life, states and institutions should make special efforts to integrate these individuals into local society and business. From our data, the payoff in increasing the number and quality of their state-based technology talent pool would be more than rewarded. It would also probably be useful to start these integrating efforts earlier in the foreign student's academic career. Within the regulations imposed on student visas, a greater frequency of interaction with state-based technology companies during sophomore and junior years might be mutually beneficial.

## Engineers and physical scientists leave

The data are relatively clear that, compared to other majors and disciplines, engineers, computer scientists and physical scientists are less likely to be retained in state-based employment after graduation. The magnitude of the effect seems to be considerable. While some of this phenomenon is likely a function of the typical career patterns of engineers, which often demand multiple job moves, it ought to be worrisome to states that have a thin supply of these highly trained technical specialists.

### Policy implications

While this group of graduating students will always be in great demand in the New Economy, states and institutions can engage in a number of practices that may decrease the rate of out-migration. Both Arkansas and Pennsylvania have targeted financial assistance programs for individuals with specific skills or backgrounds.[39] These loans become scholarships if the individual works in the state after graduation. Also, if students are engaged with local industry during the educational experience, they may be more likely to stay on after graduation. This suggests more extensive and intensive use of internship and co-op experiences with state-based industry, as well as career fairs that might be exclusively focused on state-based employers. Consistent with this view, Virginia is trying to initiate a program that will use tax incentives to create 5,000 internship opportunities with technology companies for high school and college students.[40]

## Institutional affiliation matters

The data strongly suggest that receiving a degree from a land grant school or a historically black college or university, or a higher Carnegie Classification institution for that matter, lowers the odds that one will be retained in employment in the state where one received that degree. The magnitude of this effect appears to be large but our database has severe shortcomings for understanding the underlying phenomenon. Thus we can only speculate and hypothesize. One possible explanation is that land grant schools, HBCUs and higher Carnegie institutions engage larger and more national pools of potential employers during the placement process than do other public institutions that have a more regional character. It is also possible that faculty at such institutions have a larger, more national network of employment contacts their students can tap into. Another explanation is that individuals who are more inclined to be mobile are attracted to these kinds of institutions. Similar factors may explain other institutional predictors such as degree of urbanization and size of enrollment.

### Policy implications

If further investigation confirms the validity of these findings, there are some potential solutions to increase the number of students hired in state. For example, some placement offices hold state-focused career fairs where local employers get first crack of the crop of graduating students.

## Opportunities are needed to keep or attract talent

Our study focused on factors that affect retention at the individual level. Although state economic factors did not figure prominently in our results, state population, a proxy for economic development, did predict retention. We believe, and our earlier study demonstrated, economic factors (e.g., income per capita, average technology wages) do exert an influence on retention and net migration.

### Policy implications

States that focus on the talent and ignore the opportunity side of the equation (and vice versa) do so at their own risk. On this issue we would agree with Richard Florida who concluded, "Still, the university is only one part of the system of attracting and keeping talent in an area. It is up to companies and other institutions in the region to put in place the opportunities and amenities required to make the

region attractive to that talent in the long run. If the region does not have the opportunities or if it lacks amenities, the talent will leave."[41]

## ISSUES PERTAINING TO DATA AND METHODOLOGY

This project involved the re-analysis of an excellent National Science Foundation database, the National Survey of Recent College Graduates (NSRCG) in order to explore the scope and predictors of inter-state migration of science and engineering talent. The NSRCG database was not developed for that specific purpose, but it proved, nonetheless, to be flexible and accommodating to most of our research needs. However, to the extent that we or other researchers intend to pursue this line of analysis, we believe the NSRCG could be improved with some relatively small modifications.

### Sampling strategy

The general purpose of the NSRCG is to use survey data collection to make defensible national estimates of various variables that seem to relate to the post-graduation experiences of science and engineering students in the U.S. This is a worthwhile goal, and the survey itself is very professionally designed, field data collection procedures are first rate, and the data that are made available to researchers are relatively easy to work with. However, for our purposes there are some shortcomings in how the study sample for NSRCG is currently developed. Without going into excruciating detail, the study sample is designed to be representative from a national perspective, and not necessarily for each of the states. In past STC work, we have made estimates of the value of state variables that we have constructed, albeit with some trepidation in some of the lower population states. As has been noted above, the size of the national sample for the 1997 database used in the current project was significantly reduced from that in the 1993 database. In effect, the number of observations in many of the states was too small to make methodologically defensible estimates of state parameters.

The issues raised in this study as well as in the previous Southern Technology Council report[42] have been of great interest to state-level political, academic, and economic development leadership. The NSF would be advised to make a modest investment in building a somewhat different sampling strategy that could encompass both national and state-level variables that are statistically defensible.

### Missing variables

From a more selfish perspective, it would also be useful for NSRCG to add questions reflecting variables of conceptual relevance to migration phenomena. This could be done on a one-time or periodic basis, so as not to embargo valuable questionnaire space. Several examples come to mind.

For one, it would be extremely useful to have data on the exposure of students, during their years of matriculation, to potential employers. These might include participation in internship programs, co-op experiences, industry-sponsored research projects, or placement events. The data collection might also explore the extent to which these experiences involved state-based or out-of-state employers.

Another compound rating-type question might gather data on the relative importance of various factors in deciding what job offer to take after graduation. These could be an opportunity to explore the more typical decision factors (e.g., pay, job/skill congruence) as well as personal factors (e.g., proximity to family) and other factors that seem to be more relevant to New Economy workers. The latter would

include various quality-of-life indicators, such as recreational opportunities, cost of living, crime rates, and natural beauty.

In summary, it is recommended that the NSF continue its dialogue with researchers who use the NSRCG database, and explore ways to make it more useful to address questions that are both theory-driven and public-policy relevant, particularly at the state level.

## FUTURE PUBLIC POLICY RESEARCH, ANALYSIS, AND PROGRAM DEVELOPMENT

This study, as well as others conducted by STC and other researchers in this field, has barely tapped the surface of a vein of inquiry that has significant relevance to the current economic environment. It is also a topic that is of great intuitive interest to parents, students, educators, and public policy leaders. After all, where the talented new graduate ends up spending his/her work life is of great import.

In terms of the policy recommendations discussed above, important public policy research questions need to be addressed, which in turn could lead to a more focused set of programs and policies. As follows:

1. Our recommendations concerning state scholarship programs seem consistent with the data, and make intuitive sense. However, we don't know enough about what students are being assisted by these programs, and what students are being missed. Some disciplined, quantitative evaluation research needs to be conducted on the older state scholarship programs.

2. We need better data on the best mix of institutions in a state, from the perspective of retention and attraction of out-of-staters. This gets to the nonmonetary attraction side of the stayers vs. leavers phenomenon. For example, it may prove to be the case that states should dramatically strengthen their four-year, teaching-oriented schools as much as they focus on research-intensive institutions. After all, aside from beaches, mountains and high-tech employers, the net migration champion of the country (California) also has one of the most well-developed, intersecting networks of higher education. This includes a vast community college system, the Cal State system of primarily four-year schools, and the University of California campuses. Regardless, given the importance of where one attends college on retention, it would be valuable to gain a better understanding of the factors that affect these decisions.

3. We need to better understand what is going on in students' minds, as they ponder different employment opportunities. What are the key decision factors, and when do they exert their maximum impact on choices such as attending college in or out of state or where to work? Also, what role does the large number of education, industry, and government partnerships[43] play in student's decision making? To do this properly demands more than a single point-in-time approach. What is called for is a more qualitative, anthropological methodology that can engage a significant group of student informants during their last few months of undergraduate or graduate education. Given the current project, and the growing body of relevant research in the open literature, this could be a fairly focused and productive inquiry.

## Discussion and policy recommendations

4. We need to broaden the analysis and discussion of personnel migration issues into a larger debate on social policy. While the retention and migration of talented people is of great importance in terms of technology-based economic development, the predictors thereof and the resultant policy implications have broader social policy relevance. After all, larger investments in scholarship increase educational opportunity per se. On the other hand, redirecting fixed scholarship support from need-based to merit-based uses may have the opposite effect. Paying more positive attention to foreign students may be desirable from the perspectives of both economics and public morality. A university that is more connected with its economic environment is likely to be a contributor to improvement in a variety of domains in the larger society. To the extent that nonfinancial variables (e.g., quality of life – schools, environment, sprawl) become more definitively related to vocational choices and migration, this could focus more attention to resolving these long-standing problems. In effect, personnel migration has the potential to be one of those rare, cross-cutting public policy issues that influence events far beyond the immediate and more obvious focus of activity.

## Conclusion

How important are these issues? We think they are very important. Between 1998 and 2008 employment in science and engineering occupations is supposed to increase by 51 percent or four times the rate for other occupations.[44] Jobs in the computer field will double during the same period.[45] However, production of bachelor's level scientists and engineers has been flat in most science and engineering fields recently.[46] Similar trends are apparent in master's degrees in these fields. Although enrollment in higher education is supposed to grow over the next decade, it is far from certain that the supply of scientists and engineers will meet the anticipated demand. If the current shortages of scientists and engineers persist or gets worse, a state's ability to retain its technical human capital, and not cheaper labor and various tax incentives, may decide its place in the New Economy. As one employer put it, "We think it's easier to recruit strong people if you're willing to come to the people rather than have the people come to you."[47]

# Endnotes

[1] There are any number of references that could be mentioned in this context. One of the more readable, and one that is coupled with a set of New Economy state indices, is: Atkinson, R.D., Court, R.H., And Ward, J.M. *The State New Economy Index: Benchmarking Economic Transformation in the States.* Washington, D.C.: Progressive Policy Institute, 1999.

[2] See Office of Technology Policy, Technology Administration, U.S. Department of Commerce. *The Dynamics of Technology-Based Economic Development, State Science and Technology Indicators.* Washington, D.C.: U.S. Department of Commerce, June, 2000.

[3] For instance see: DaVanzo, J. (1983). Repeat migration in the United States: Who moves back and who moves on? *The Review of Economic Statistics*, *65*, 552-559; Greenwood, M.J. (1969). An analysis of the determinents of geographic labor mobility in the United States. *Review of Economics and Statistics*, *51*, 189-194.

[4] For instance see, Ballweg, J.A.& Li, L. (1992). Employment migration among graduates of southern land-grant universities. *Southern Rural Sociology*, *9*, 91-102; Fryman, J.F. (1988). Factors in the interstate migration of college students. *College and University*, *63*, 234-247; Greenwood, M.J.(1973). The geographic mobility of college graduates. *The Journal of Human Resources*, *8*, 506-515.

[5] See Tarant, S. (2000). *State retention of recent college graduates in science and engineering: Implications for organizational recruiting and selection practices*. Unpublished master's thesis proposal, Department of Psychology, North Carolina State University, Raleigh, N.C.

[6] For instance, see: Rousseau, D.M. (1985). Issues of level in organizational research: Multi-level and cross-level perspectives. In B.M. Staw & L.L. Cummings, (Eds.). *Research in organizational behavior*, 7, 1-37, JAI Press.

[7] The database included degree recipients in several dozen majors organized into the braod categories of computer and mathematical sciences, life sciences, physical sciences, social sciences and engineering.

[8] The target population included residents of the United States with at least a bachelor's degree and who, as of the survey reference period were non-institutionalized, under 76 years of age.

[9] The vast majority of respondents dropped at this step were classified as students during the target week.

[10] Although the original sampling frame was intended for recent graduates who received either a bachelor's or master's degree during the survey time period, the two year time frame actually allowed a small number of respondents to complete an advanced degree (doctoral or other professional). To maintain homogeneity of degree recipients, respondents who indicated receiving a doctoral or other professional degree as their most recent degree were eliminated from the sample (n=32). Respondents who reported receiving their most recent degree from an institution outside the U.S. (n=3), received a non-science or engineering degree (n=53), or were missing grade-point-average data (n=11) were also removed from the analyses. In addition to these constraints it was necessary to exclude respondents missing data for state in which high school degree was received, state in which most recent degree was received, or state of current employment.

[11] A more detailed description of the weighting scheme can be found in: *Design and Methodology*, SESTAT surveys database, National Science Foundation. On the Web at: http://www.civic.com/civic/articles/2001/feb/civ-blues-02-01.asp.

[12] Institutional data were obtained from the *Institutional Characteristics 1997-98 Survey*. The National Center for Education Statistics (NCES) surveys all postsecondary institutions in the 50 states, District of Columbia, and outlying areas. The IC Survey was sent to 4,176 eligible universities within the 50 states and the District of Columbia and its outlying areas. Of those institutions, 4,025 responded for a total response rate of 96.4%.

[13] It's important to realize that these outcome variables overlap to some extent. Individuals who receive their most recent degree from the same state that they receive their high school diplomas (representing a variable, Stayer) will be coded as "retained" in both measures. Thus, one would expect a high but not perfect correlation between our two outcome measures and a fair amount of covergence in the predictors for both.

[14] A state-level measure of tuition (charged by state universities) was not tested because a more precise institutional measure of tuition was available.

[15] Atkinson, R., Court, R., & Ward, J. (1999). *State of the new economy: Benchmarking economic transformation in states*. Washington, DC: Progressive Policy Institute

## ENDNOTES

16 *Places rated Almanac*, 5th Edition., MacMillan, 1997.

17 All measures reflect the target week of 1997.

18 See Shelley, M.C., & Koven, S.G. (1993). Interstate migration: A test of competing interpretations. *Policy Studies Journal*, 21, 243-261.

19 In order to construct state-level quality-of-life indices, we created average quality of life measures for every state based on the five largest metropolitan areas using data contained in *Places Rated Almanac, 5th Edition, MacMillan, 1997*

20 Logistic regression is a form of multivariate analysis that is specifically designed for use with discrete dependent measures. Logistic regression provides more flexibility and is more appropriate to use with categorical dependent variables than other multivariate techniques. These procedures allow us to predict the log-odds of falling into one rather than the other category, and logistic procedures make no assumptions about the distribution of the independent variables included in the model. Unlike other types of multiple regression, the logistic method uses chi square statistics to evaluate model fit. For additional background on logistic regression refer to: Tabachnick, B.G. & Fidell, L.S. (1996) *Using multivariate statistics*. NY, NY: HarperCollins .

21 Numbers for retention most recent degree are similar. On average, 37.8 % wind up working in another state; retention by state ranges from 10% to 84%.

22 The size of the NSRCG sample declined from 19,426 in 1993 to 10,057 in 1997. While the resulting sample is sufficiently robust for national estimates it precluded STC team from computing a complete set of state-level indices on retention and migration as was done with the 1993 database. The simple problem was for many states the sample was too small to permit defensible estimates of state level retention and migration.

23 For those not statistically inclined, a correlation is used to describe the degree of relationship between variables. Usually expressed as the Pearson correlation coefficient (r), it can range in value from 0.0 to 1.0 with 0 indicating no relationship and 1 indicating a perfect relation. Since correlations can be either positive or negative, the effective range is –1 to +1. In the realm of policy analysis, values closer to zero are more common.

24 Because this analysis includes states with large samples it includes primarily larger states. Our previous study demonstrated larger states have higher retention rates. This results in a "restriction of range" in the retention measure that typically results in underestimating the real correlation between two variables. For more detail on this issue see: Nunnally, J. C. (1967). *Psychometric Theory*. NY: McGraw-Hill.

25 Table 3 only presents comparisons to engineering. Other comparisons (e.g., life science to physical science) were calculated separately.

26 The only other effect worth noting is that Social Science majors are significantly more likely to be retained than Life Science and Computer/Math majors.

27 A post hoc analysis of this effect which divided students into either math or computer science majors revealed that computer science majors were closer to engineers and physical scientists in terms of retention.

28 Economic dynamism is an abstract and complex index. In order to help elucidate what this measure is tapping into we list the top and lowest 5 states. Highest: Nevada (1), California, Colorado, Arizona, New Mexico. Lowest: Iowa (50), Montana, Alaska, West Virginia, Wyoming.

29 Citizenship was not tested for Retention/High School because the overwhelming majority of foreign students did not attend high school in the U.S. This made evaluating retention impossible. In contrast, since foreign students in this sample graduate from U.S. higher education institutions in a particular state, this variable could be evaluated for Retention/Most Recent Degree

30 This requirement was part of the NSF NSRCG data collection effort and applied to all respondents.

31 National Science Board (2000). *Science and Engineering Indicators –2000*. Washington, D.C.: National Science Foundation.

32 Differences were also observed in some comparisons between racial groups. However, these were difficult to interpret and will not be discussed here.

33 Individuals who listed their major or minors as computer science or listed their employers business as "information technology" were coded as information technology workers/skills

34 Foreign-Permanent Resident was significant in the full model at $p<.03$.

35 McPherson, M.S. & Schapior, M.O. (1999). Gaining control of the free-for-all in financial aid. *The Chronicle of Higher Education*, July 2, pg. A48, Point of View.

## Endnotes


[36] Florida, R. (1999). The role of the university: Leveraging talent, not technology. *Issues in Science and Technology,* 15, pp 67-73.

[37] National Science Board (2000). *Science and engineering indicators –2000*. Washington, D.C.: National Science Foundation.

[38] Florida, R. (1999). The role of the university: Leveraging talent, not technology. *Issues in Science and Technology*, 15, pp 67-73.

[39] Berglund, D. &Clarke, M. (1999). *Using research and development to grow state economies*. Washington, D.C.: National Governors' Association Best Practices Series.

[40] Ibid.

[41] Florida, R. (1999). The role of the university: Leveraging talent, not technology. *Issues in Science and Technology*, 15, pp 67-73.

[42] Tornatzky, L., Gray, D., Tarant, S. and Howe, J. *Where Have All the Students Gone? Interstate Migration of Recent Science and Engineering Graduates.* Research Triangle Park, N.C.: Southern Growth Policies Board, 1998.

[43] National Science Board (2000). Science and engineering indicators –2000. Washington, D.C.: National Science Foundation.

[44] National Science Board (2000). Science and engineering indicators –2000. Washington, D.C.: National Science Foundation.

[45] National Science Board (2000). Science and engineering indicators –2000. Washington, D.C.: National Science Foundation.

[46] National Science Board (2000). Science and engineering indicators –2000. Washington, D.C.: National Science Foundation.

[47] O'Brien, C. (1998, September 9). "Triangle talent lures Torrent". Raleigh, News and Observer, pg. 1-D, 8-D)

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(919) 941-5145 ● www.southern.org ● Fax (919) 541-5594