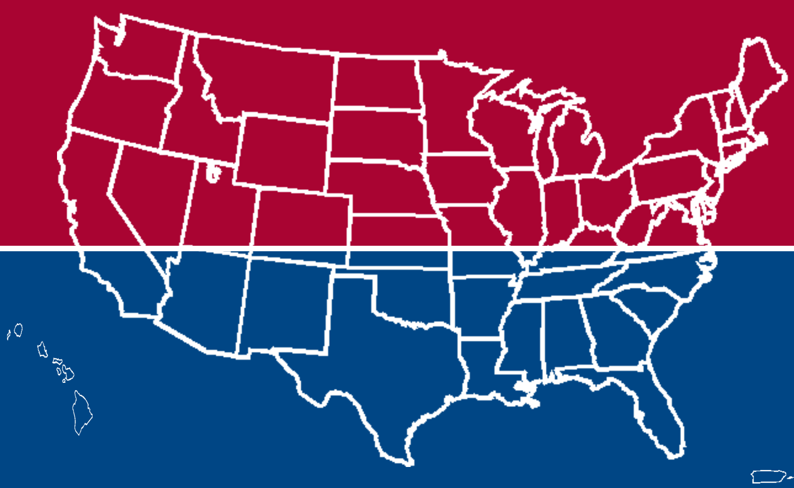
Where Have All the Students Gone?

Interstate Migration of Recent Science and Engineering Graduates



A Benchmarking Report
of the Southern Technology Council
A Division of the Southern Growth Policies Board

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Executive Summary

Recent science and engineering graduates can make huge contributions to state and national economies, both in terms of human resources for existing high-tech businesses and often as entrepreneurs creating new businesses and new jobs in the global economy. This report focuses on the role of these highly skilled people in state economic development and, in particular, about their migration patterns across state lines and what contributing factors may put certain states or regions at a disadvantage.

This study grew out of a series of discussions in 1995 among members of the Southern Technology Council, a division of the Southern Growth Policies Board charged with strengthening the Southern economy through technology. At that time, a number of acute shortages were appearing in certain engineering and science disciplines in parts of the South, primarily in the computer, electronics, telecommunications, and information systems industries. There appeared to be relatively little in the research literature that spoke in terms of state level analyses of the retention and movement of the technology worker, although there were some studies that focused on related issues. There has been little analysis focused on post-graduation migration patterns, particularly as they pertain to employment, which are of primary interest from an economic development perspective.

The Southern Technology Council conducted a state-level analysis of data collected as part of the National Survey of Recent College Graduates (NSRCG).[1] Using the NSRCG data, state indices were developed for (1) **retention** of one's own recent science and engineering graduates; and (2) **net** interstate **migration** of recent science and engineering graduates. Descriptive and predictive analyses were performed. Predictive analyses used state-level geographic, economic, and policy variables.

Some of the key findings are:

- There are large disparities across states in both net retention and net migration of recent science and engineering graduates. Moreover, retention and migration seem to be distinct phenomena with different contributing factors.

- Geographic factors seem to be a significant predictor of retention and net migration of recent science and engineering graduates, more so with regard to retention. For example, larger more populous states and states with less "permeable" borders (in terms of commuting patterns) retain a higher percentage of their graduates than do smaller states with permeable borders.

- State economic indicators, such as higher wages and, in particular, higher wages in the technology sector, seem to be positively related to net migration.

- The fraction of a state's high school graduates who stay home to attend college is a relatively powerful predictor of retention and net migration patterns, although in somewhat contradictory directions.

- Lower tuition—both in-state and out-of-state—at public universities appears to function as an important magnet for positive net migration of science and engineering graduates.

- Federal defense spending, but not other federal investments, has a moderate impact on net migration.

Several recommendations are:

- States and/or universities should benchmark measures of retention and net migration on an ongoing basis.
- States should accelerate their efforts to build high-wage technology-based economies if they wish to retain their own best and brightest students and attract highly skilled people from elsewhere.
- States that are losing graduates should give serious consideration to lowering, or at least stabilizing, tuition levels at public universities. In addition, the expansion of financial assistance in key science and engineering disciplines might be considered.
- Additional research and qualitative analysis is needed on this important topic. Future efforts should focus on more specific programmatic initiatives that states can undertake to retain or attract the best and brightest science and engineering graduates.

Introduction

The New Economy

The U.S. economy is currently in the middle of one of the most prolonged and robust periods of growth it has experienced in decades. Moreover, this growth is accompanied by negligible price and wage inflation as well as increasing evidence of public sector discipline on issues of taxation, spending, and regulation.

To explain this relatively blissful state of affairs, the notion of a "new economy" has received increasing currency among both the lay person and the policy communities. This new economy is presumed to have several key characteristics:

- Economic growth is increasingly tied to technology, with U.S. firms doubling their R&D intensity (as a percentage of sales) over the last 15 years and with technology-based companies and industries (e.g., chemicals and pharmaceuticals) showing the most rapid increases in international market shares and overall growth;[2]

- The new economy is a global economy that is enabled by advances in transportation and communications technologies and that produces an increased share of trade-related business for the most rapidly growing companies;

- Entrepreneurial small companies are playing an increasing role in the economy, accounting for a disproportionate share of job creation, new product innovations, and aggressive positioning in international markets; and[3]

- The emerging economy places a premium on highly trained and skilled people with backgrounds in scientific and technical disciplines. In study after study, high growth companies identify the lack of trained professional and technical personnel as both their primary area of need and the major road block to maintaining their current level of expansion.

However, there are dramatic interstate and regional disparities in the extent of participation in the new economy. For example, a recent analysis by the American Electronics Association[4] indicated that of the 15 member states of the Southern Technology Council (including the Commonwealth of Puerto Rico), only four could be considered among the national leaders in building technology-based state economies. This minimal level of participation in the new economy is shared by other states in other regions and is reflected in metrics such as the fraction of private sector workers employed by high-tech firms and the rate of high-tech employment growth. This picture is paralleled by state data developed by the National Science Foundation[5] that indicates significant disparities in the industrial R&D intensity of state economies and in involvement in intellectual property activities such as patenting.

This report focuses on only one of the critical ingredients of the new economy characterized above: the role *highly skilled people*—i.e., recent science and engineering graduates—play in state economic development and in particular, how this precious commodity moves across state lines.

The Southern Technology Council, formed in 1986, is a division of the Southern Growth Policies Board concerned with technology creation, transfer, and application in the South. The mission of the STC is to strengthen the Southern economy through technology. Participating in the Southern Technology Council are: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, Virginia, and West Virginia. Each is represented on the Council by two people appointed by their governor. In addition, the STC has corporate and nonprofit members, and their representatives also participate fully in the work of the STC.

This Analysis in Context: Past STC Benchmarking Efforts

Since 1993, the Southern Technology Council has been benchmarking various aspects of building a technology-based modern economy. This has included an examination of the technology transfer performance (through patenting and licensing) of research universities in the region,[6] documentation of best practices in technology business incubation,[7] and an analysis of exemplary policies and practices in implementing educational technologies in K-12 schools.[8] The goals of such benchmarking are twofold: (1) to understand the relative performance among peer institutions (e.g., states, universities) in mastering various aspects of a technology-based economy; and (2) to identify and describe the keys to improvement.

This report is part of that larger body of work and focuses its analysis on state-level performance in retaining and attracting highly skilled personnel. It also makes a preliminary attempt to determine some of the factors contributing to the retention and interstate migration of entrants to the science and engineering workforce.

The Key Role of Highly Skilled People

In 1993-1994, state governments in the U.S. spent $41.9 billion on higher education at all levels. In parallel, parents and students spent another $48.6 billion on tuition at both public and private institutions of higher education across the country.[9] While there are many reasons why individuals and institutions provide support for and/or participate in higher education, many of them focus on economics and geography. For example, most parents have the fairly straightforward aspiration that their sons and daughters will become appropriately skilled and credentialed at a college or university so that they can secure meaningful, well-paying jobs, ideally within a three-hour drive from home. Similarly, state-based companies have an interest in their state's higher education system as a source for new expertise in areas of science and technology of particular business relevance. Finally, stakeholders in state government have some hopes and expectations that a significant fraction of science and engineering graduates from state-based institutions—which have been significantly subsidized by state taxes—will be able to find appropriate jobs locally and contribute to the state economy.

It is important to understand the huge contributions to state and national economies that recent science and engineering graduates can make. As suggested above, as the economy becomes more entrepreneurial, an increasing percentage of graduates are forsaking a career of working for others and plunging headlong into launching new enterprises. A recent analysis by BankBoston on the impact of MIT graduates provides the most startling evidence of how graduates can contribute to regional and national economies. The study found that MIT graduates "have founded 4,000 firms which, in 1994 alone, employed at least 1.1 million people and generated $232 billion of world sales."[10] Taken together, these companies founded by MIT graduates would constitute the 24th largest economy in the world. Of particular note, when asked about the principal determinants regarding where they located their company, among the highest responses were "access to skilled professionals," "proximity to principal markets," and "quality of life."[11] This finding underscores the relevance of the current study. If founders of MIT-related companies indicate that human resources are way up on the list of criteria for location and relocation, then this ought to be an important issue for state economic development policy as well.

Some would argue, of course, that graduates from institutions such as MIT are in a class by themselves and that one cannot draw inferences from their experience. Nonetheless, it seems a reasonable assumption that every college or university involved in training in the sciences and engineering is producing a number of the best and brightest in these fields. The analytic challenge is to better understand the geographic migration of this precious human commodity and to make an initial attempt to understand factors contributing to the phenomenon. In approaching these questions, we assume that the free movement of labor in a market economy is a desirable state of affairs and that no state can or should erect policy barriers that inhibit that movement. Nonetheless, to the extent that a state can act as a magnet for highly talented people, its social and economic prospects should be enhanced.

What Do We Need to Know?

This study grew out of a series of discussions in 1995 among members of the Southern Technology Council. At that time, a number of acute shortages were appearing in certain engineering and science disciplines in various sub-regions of the South. The impacted companies primarily involved computers, electronics, telecommunications, and information systems. Their shortages pointed to the relative dearth nationally of recent graduates in disciplines such as electrical engineering and computer science.[12] This interest was accentuated by recent regional analyses confirming the close linkage between personal income and educational level.[13] This led to a larger discussion about the migration of highly skilled individuals across state lines and what might be contributing to migration patterns that put certain states or sub-regions in the South at a disadvantage.

Relatively little appeared in the research literature that spoke directly to these types of questions, although some studies focused on related issues. For example, one analysis of the inter-regional migration of defense scientists ties migration patterns to the concentration of defense contracts across the states.[14] Another analysis looked at the relationship between the location of industry R&D labs and commensurate spending on university research as well as on state science and technology programs.[15]

Other studies looked more closely at the interstate migration of college students, at both the undergraduate and graduate levels, and at how the choice of a college is influenced by various institutional policies.[16] One study found that in-migration to universities by out-of-state students is influenced both by non-resident tuition fees as well as by general economic conditions in the state that is the destination for migration.[17] However, there has been little analysis focused on post-graduation migration patterns, particularly as they pertain to employment, which are of primary interest from an economic development perspective. While there is some evidence that, all things being equal, people with technology backgrounds will tend to remain working in the area where they receive their college degree,[18] the fact is that all things are probably *not* equal in retention patterns across states nor in the factors determining migration behavior. While there have been some state-level analyses of human resources "report cards",[19] they have not focused explicitly on the technology-based economy. In summary, the current research literature is incomplete in terms of state level analyses of the retention and movement of the technology worker.

As a first step in answering these questions, staff at the Southern Technology Council explored the feasibility of obtaining primary data on the geography of post-graduation employment from universities themselves. As part of another benchmarking analysis on university technology transfer performance among institutions in the South,[20] we asked survey respondents if they could provide information on their number of recent science and engineering graduates as well as on what fraction of those graduates were currently employed in the institution's home state. We quickly discovered that few universities systematically track such information, at least at the institutional level. More often, this information is developed by alumni support organizations, many of which operate at the department or college level. Not surprisingly, there is also little commonality among institutions on how they gather and organize such information.

The Southern Technology Council decided to undertake an analysis of existing databases that would address the following questions about science and engineering graduates:

1. Looking at post graduation employment, to what extent do states *retain* their own science and engineering graduates in jobs in state-based companies or organizations?
2. To what extent do states not only retain their own graduates but also function as a magnet for the graduates from other states, thus enhancing their net migration of high-skill human resources?
3. What is the relative ranking of states, and logical groupings of states, across the U.S. on these performance measures?
4. What are the factors contributing to retention and positive *net migration* of recent science and engineering graduates, and can they be influenced by state policies or programs?

Method

General Approach

Fortunately, the research team was able to identify and use an existing database, the National Science Foundation's National Survey of Recent College Graduates (NSRCG), appropriate to some of our analytic concerns. The basic approach was to develop methodologically defensible outcome indicators of personnel retention and migration, as defined by the state in which recent science and engineering graduates are now employed, and then conduct descriptive analyses on those metrics. Additionally, the team identified variables in several areas in order to conduct predictive analyses of the retention and migration outcomes.

In summary, descriptive analyses were performed on job-related retention of recent science and engineering graduates and on the net migration of those graduates. Second, predictive analyses were performed on factors contributing to both of these outcomes.

The National Survey of Recent College Graduates

The National Science Foundation's National Survey of Recent College Graduates (NSRCG) migration and retention indices is a national probability survey of Bachelor's and Master's science and engineering degree recipients.[21] Formerly called the 'New Entrants Survey,' it is designed to provide data on the demographic, educational, and employment characteristics of recent degree recipients entering the science and engineering labor market and on their current status. To develop our analyses, we used data from the most recent NSRCG database available, which included students who received their degrees during the Spring of 1990 and the academic years 1990-1991 and 1991-1992. These former students were interviewed for the NSRCG sometime between November 1993 and May 1995 about their status as of the "target week," April 15, 1993.

Study Sample

The sampling of academic institutions and their graduates for the NSRCG was conducted by the Institute for Survey Research (ISR) at Temple University. A two-stage sampling strategy was used; the first stage involved the selection of 275 institutions that would constitute the sample of organizations, and the second stage involved the selection of a sample of 25,785 recent graduates from those 275 universities and colleges. Of these graduates, 19,426 qualified respondents provided data, for a highly respectable response rate.[22]

In the first stage, all colleges and universities in the U.S. offering Bachelor's and/or Master's degrees in science and engineering were identified, and a smaller study sample of institutions was selected, based on size. Thus, 196 of the largest universities and colleges, which train the vast majority of the nation's science and engineering graduates, were included. A sub-sample of 79 smaller institutions was selected as well. This included a number of colleges offering relatively rare major specialties in science or engineering and that were sampled with a probability proportional to the size of their enrollments. In addition, a number of smaller universities with a high proportion of Hispanic, African-American, and other minority students were also over-sampled. Therefore, consistent with the survey's goals, 275 large and small institutions offering Bachelor's and/or Master's degree programs in the science and engineering fields provided the sample of organizations. (It should be noted that the study sample of the NSRCG did not include doctoral degree recipients. It would be inappropriate to generalize our findings to that population.)

In the second stage of the sampling design, individual graduates from the 275 selected institutions were sampled. Individuals were selected on the basis of a formula that included the size of their institution, the level of degree they received, the year they received their degree, and their specific field of study. ISR first obtained lists of graduates who received Bachelor's and Master's degrees between 1991 and 1992 from those institutions selected to be part of the study.[23] Graduates were classified according to their major field of study and the level of their degree and then individually selected according to a formula that ensured the final sample would contain respondents from all 275 institutions, in all major science and engineering fields for both Bachelor's and Master's degrees in each year, and at a rate commensurate with the size of the institution. Westat, Inc., refined the sample by insuring that respondents met all eligibility requirements and by applying a weighting scheme[24] to the data to adjust for any unequal selection probabilities and non-responses rates; this 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.[25]

Since we were interested in the states in which students were employed after graduation, we also limited our analyses to respondents who were employed during the target week in 1993. This resulted in a final effective sample of 14,526. (The vast majority of respondents dropped were classified as students during the target week.)

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 hard copy 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 number 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.[26] Each section of the survey involved a number of specific questions organized in a branching format, and an individual participant could potentially supply information on well over 200 questions (although most did not because not all questions applied to all respondents). Most questions were either fill-in-the-blank requests for information, checklists, or rating scales.

Data collection was conducted from November 1993 through May 1995. 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 were also mailed to hard-to-reach respondents.

Unit Of Analysis

As described above, the NSRCG database that formed the basis for our analyses was derived from questionnaire responses from recent college graduates. However, in our study, these data were then aggregated by state, and the basic unit of analysis for statistical purposes was the state—not individuals or specific universities.[27] Furthermore, our findings are focused on those former students who were working as of the target week of April 15, 1993.

Benchmarking Indices: Interstate Personnel Retention and Net Migration

For the purposes of our study, the basic outcome benchmarks were constructed from data on: (1) the states in which individuals in the NSRCG database received their high school diplomas and college degrees;[28] and (2) the state in which they were employed during the target week follow-up period. As noted above, individual-level data were aggregated by state; for the descriptive, comparative, and predictive analyses reported below, the states, plus the Commonwealth of Puerto Rico, were the units of analyses.[29]

Given this approach, the four key state-level outcome benchmarks were calculated using fairly simple formulas (see *Appendix A*), as follows.

1. Retention/Most Recent Degree. This benchmark variable was calculated by dividing the number of respondents in the sample who received their most recent degree (Bachelor's or Master's) in the target state and were working in *that* state at follow-up by the number who received their most recent degree in the target state and who were working in *any* state. It should be realized that a state's "retained" population could consist of both natives who went to in-state universities and then stayed on in employment plus individuals who received their high school degree elsewhere and who were attracted to a target state's university and employment. These latter might be considered "converts." Theoretically, this variable can range from zero (if a state lost all its graduates) to one (if a state retained all its graduates).

2. Retention/High School. This benchmark variable was calculated by dividing the number of respondents who received their high school diploma in the target state and were working in *that* state at follow-up by the number who received their high school diploma in the target state and who were working in *any* state. The components of the high-school-retained population are severalfold, and the label is somewhat of a misnomer. For one, it includes natives who have simply stayed in their home state after high school, gone to college there, and stayed on in employment. It also includes individuals who went to high school in-state, left to take a Bachelor's or Master's degree in another state, and then returned for employment. The latter might be considered "repatriated." This variable also can range from zero to one.

3. Net Migration/Most Recent Degree. This benchmark variable was calculated by dividing the number of respondents in the database who got their most recent degree from any state but who were currently employed in the *target state* at follow-up by the number who received their most recent degree in the target state and who were working in *any* state. In essence, this index quantifies the "net" of state-based job holders relative to science and engineering graduates produced by the state's colleges and universities. If a state's index is below one, a state is educating some individuals who take jobs elsewhere as well as attracting fewer graduates from other states. If a state's index is above one, the state is employing more graduates than it produces and is a net importer. The likelihood of a state being a net importer is a function of two sub-populations: (1) those individuals who received their degrees in the state and stayed on in employment; plus (2) those who received their degrees elsewhere and were attracted to the state for employment. The former might be thought of as "homebodies" and the latter as "fresh conquests."

4. Net Migration/High School. This benchmark variable was calculated for each state by dividing the number of respondents in the database who got their high school degree from any state but who were currently employed in the target state at follow-up by the number who received their high school diploma in the target state and who were working in any state. This index quantifies the "net" of state-based job holders relative to science and engineering college graduates who are also products of the state's high schools. As above, the value of this index relative to one (the break-even point) is influenced by the size and movement of various sub-populations of graduates. For example, if a large number of individuals leave a target state after high school (or college) and never return for jobs, this index would be deflated. Since the numerator in both this index and the index above are the same, the value of each is determined by the denominators—the number of college or high school graduates, respectively. Thus, a state's two migration indices could differ substantially depending on the nature of its educational investments and activities.

To summarize the logic of the outcome benchmark indices, retention measures provide a crude measure of the extent to which a state can capture the economic potential of specific individuals who have been educated within its borders, often at taxpayer expense. Migration indices provide a measure of the extent to which a state can leverage its retention potential via the attraction of talented young people from elsewhere. Both of these types of measures are admittedly cumbersome proxies for the complex set of phenomena that are played out in the lives of the individuals involved. Nonetheless, they are a first approximation to a key component of states' competitive posture in the emerging global economy. For those readers interested in the statistical cautions regarding these data, we would encourage them to get into the more expansive endnote that has been provided.[30]

Predictive Analysis of Retention and Net Migration

While it is useful to understand how states are performing relative to each other in terms of retaining their own high school and college graduates and in terms of net migration patterns, it is even more helpful to understand *why* these differences exist. As noted earlier, other researchers have looked at migration. However, these prior studies mostly focused on individual-level predictors (e.g., characteristics of the student or worker such as their age or their SAT scores) or economic variables operating within a whole region of the country. In contrast, we choose as our predictors a variety of *state-level* structural, economic, and policy variables. In principle, at least some of these variables should be under local control.

We limited our predictive analysis to variables from six categories (the specific predictor variables are listed in *Appendix B*[31]), as follows:

1. Geographic Characteristics. **Geographic characteristics**, such as size and density of the population, were examined, as was a proxy for the "permeability" of a state's borders, as measured by the fraction of residents employed in another state. For example, if a state shared borders with several adjoining states, particularly borders involving interstate urban areas, this might impact the retention and migration of high-tech workers (although individual states can usually do little to influence these variables).

2. Industrial Structure. Variables indicative of the **industrial structure** (e.g., manufacturing vs. service) of a state were included under the assumption that certain industries might be better employers of individuals with science and engineering degrees.

3. State Economic Performance. By similar reasoning, we also examined several variables that are indicators of **state economic performance**. All things being equal, a robust state economy might be assumed to be more attractive to science and engineering graduates.

4. Federal Spending. As suggested by the research literature, the team also looked at several indicators of **federal spending** by state. Since some fraction of this is likely to be technology-related (e.g., large federal R&D facilities), it might be a factor in the retention and migration of science and engineering graduates.

5. R&D/Technology Intensity. At a more precise level of economic predictors, we also looked at several measures of the **R&D/technology intensity** of state economies. The plausible link to retention and migration of recent science and engineering graduates is obvious. While any job-seeking recent college graduate is likely to be interested in the general robustness of a state economy, one can hypothesize that those with a science or engineering degree might be even more interested in specific industries or technology-based companies. In fact, they might be aggressively recruited by the latter.

6. Policy Variables. Finally, we also examined state educational investments and **policy variables** under the assumption that there are a number of actions that states can take to make their institutions more attractive to students. We surmised that ensuring a student attends a state-based college or university might be a good strategy for guaranteeing the individual stays on in employment after graduation. Accordingly, we looked at predictor variables such as tuition levels and state support for higher education.

Figure 1

Retention Index/ Most Recent Degree

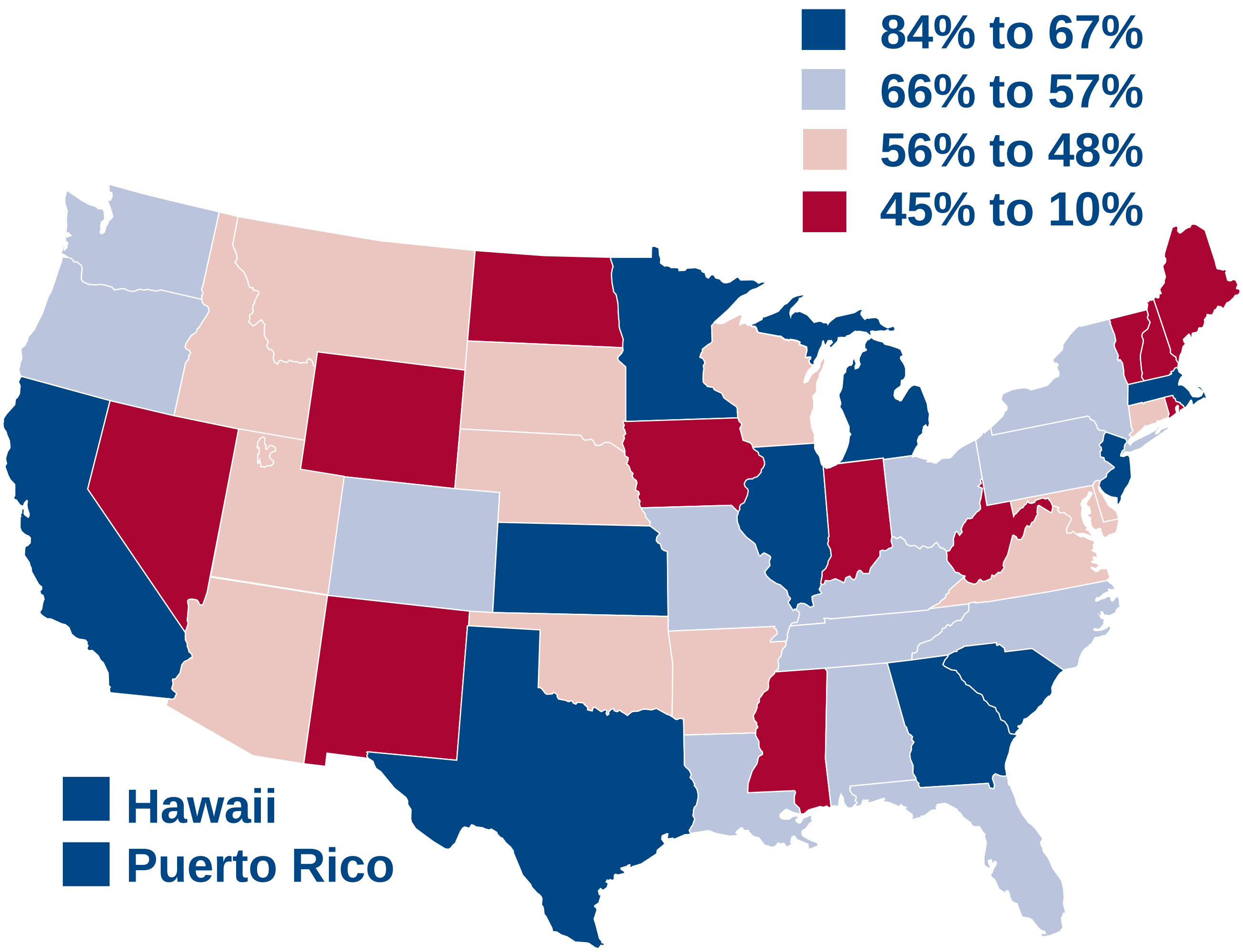


Figure 2

Retention Index/ High School

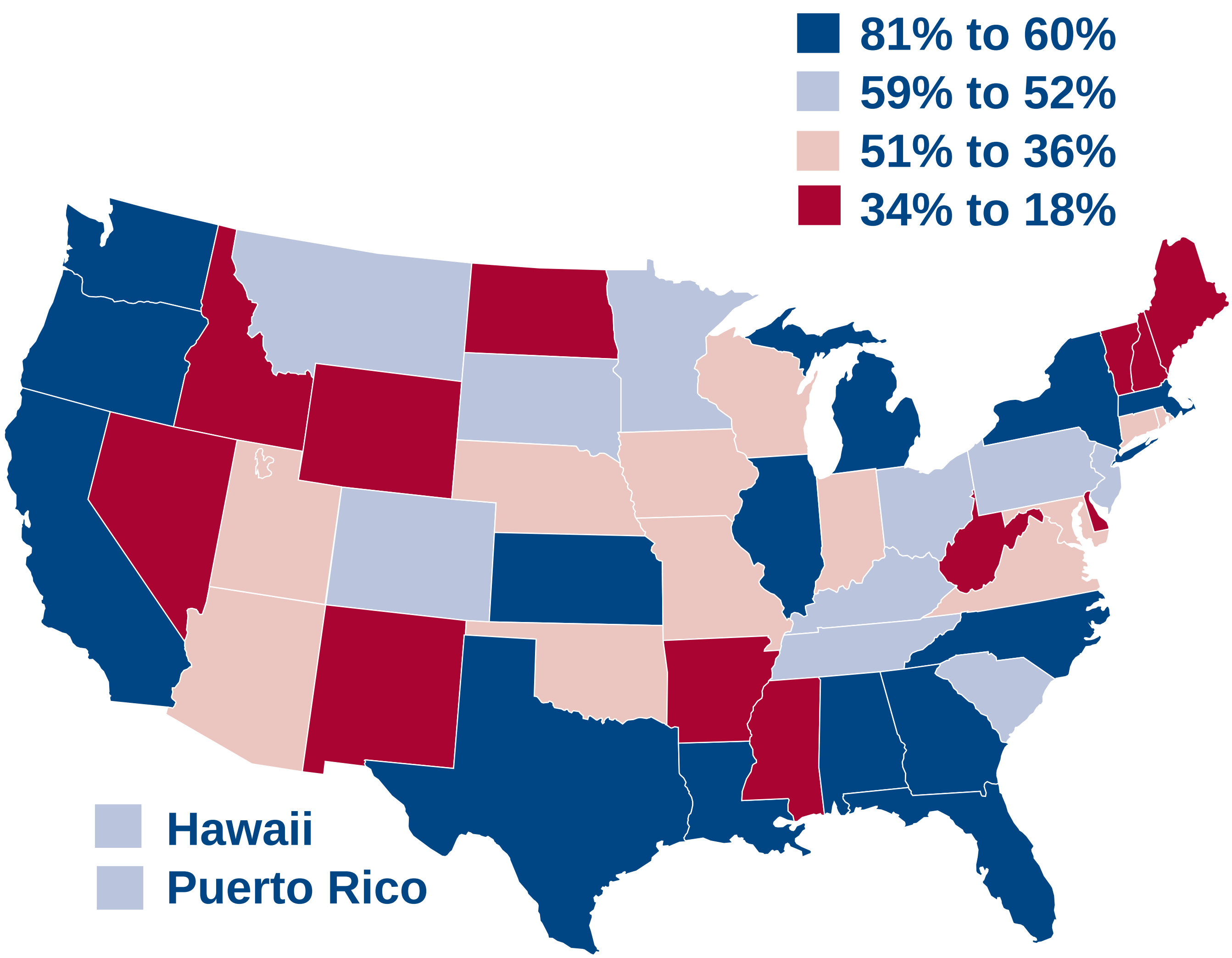


Figure 3

Net Migration Index/ Most Recent Degree

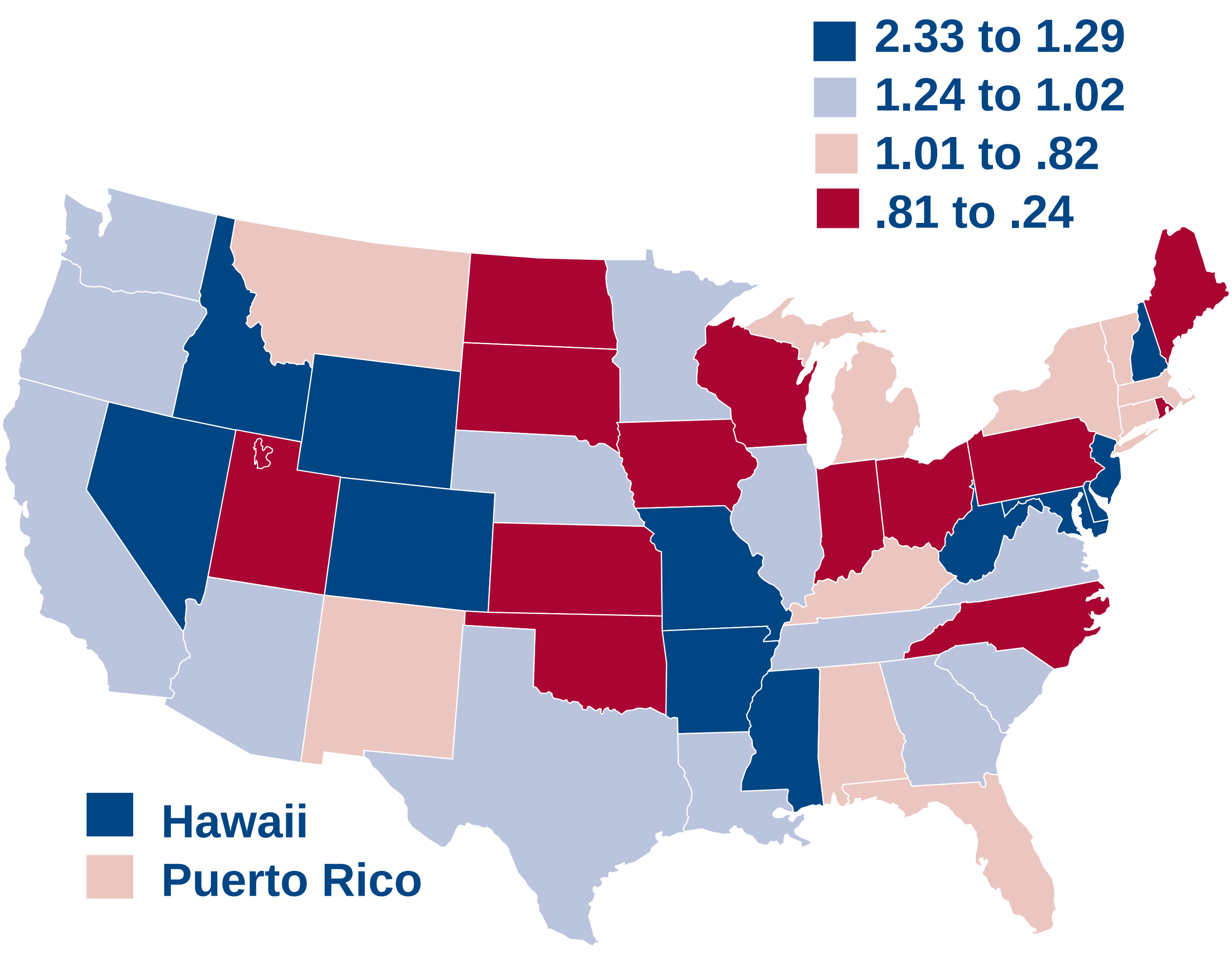
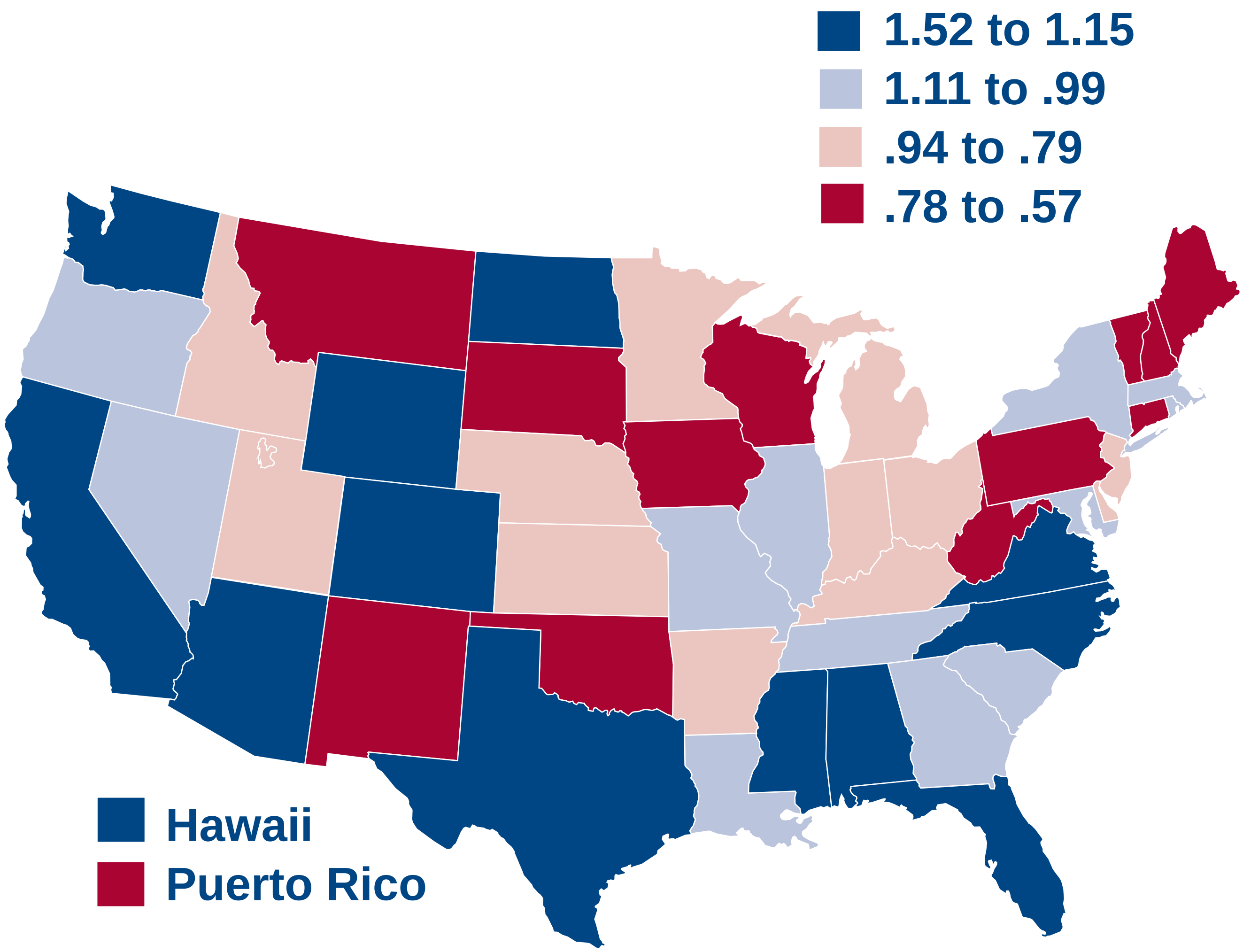


Figure 4

Net Migration Index/ High School



Analyses And Results

Overview of Analyses

The data were analyzed and are presented from two different perspectives: (1) a descriptive benchmarking analysis; and (2) a predictive analysis. These differed as follows:

Descriptive Benchmarking Analyses. The purpose of the performance benchmarking is to see how individual states compare in terms of the retention and net migration indices. In addition, there is also some comparison of sub-groups of states, most notably EPSCoR states versus non-EPSCoR states[32] as well as Southern states compared to states elsewhere in the country.[33] The summary descriptive results are provided in *Figures 1-4* on pages 11-14.

Predictive Analyses. The purpose of the predictive analyses is to identify a small group of predictor variables that might explain as much variance as possible in the retention and migration indices. To achieve this, we pursued an exploratory predictive analysis strategy that identified variables correlating[34] at an acceptable level of statistical significance[35] with the benchmarking measures of retention and migration and then refined that list via multiple regression procedures[36] until we obtained our final list of predictors.

Results: Descriptive Benchmarking Analyses

Relationship Among Dependent Variables. Before we discuss our descriptive results, it is worth exploring how highly related the retention and migration measures are to one another. *Table 1* shows the correlations between the four dependent variables. Interestingly, only the *Retention/High School* and *Retention/Most Recent Degree* indices appear to be very highly correlated (r = .85). *Retention/High School* is significantly correlated with *Net Migration/High School* (r = .44), but *Retention/Most Recent Degree* is not correlated with *Migration/Most Recent Degree*.

TABLE 1

Correlations Between Outcome Variables

	1	2	3	4
1. Retention/Most Recent Degree	—	.85**	.04	.40*
2. Retention/High School	—	—	-.22	.44*
3. Net Migration/Most Recent Degree	—	—	—	.26
4. Net Migration/High School	—	—	—	—

Significance levels:

** $p \leq .001$
* $p \leq .01$

These results are important for several reasons. For one, the statistics suggest that we are really looking at qualitatively different and distinct phenomena. With the exception of our two retention measures, one would therefore expect states to perform well on some indices and not on others and for different predictors to explain each benchmarking index. For example, the data suggest that states able to retain their own high school graduates in the workforce after they graduate from college are not necessarily very effective at attracting individuals who get their degrees elsewhere in the country ($r = -.22$ between *Retention/High School* and *Net Migration/Most Recent Degree*).

Descriptive Results—Retention. As described above, there are two benchmarking measures for retention: (1) *Retention/Most Recent Degree*; and (2) *Retention/High School*. The basic descriptive results are displayed in *Figures 1* and *2*, and as can be seen, there is a huge *range* of state-level retention performance.

For *Retention/Most Recent Degree*, the highest state (California) retains an estimated 84 percent while the lowest state retains a mere 10 percent. When retention is computed in terms of *Retention/High School*, the range of state-level performance is only slightly less extreme going from a high of 81 percent to a low of 18 percent. These disparities across states have serious implications for state economic development, and the ranking of states across the two indices is relatively consistent. In effect, the lower-performing states are educating in their high schools, colleges, and universities individuals who accept employment elsewhere. Whether these students are replaced by in-migrants from other states is reflected in our migration indices.

In addition to developing state-level retention statistics, the team also performed some comparative analyses in terms of groups of states. Given the historic focus of the EPSCoR program on those states which are less research-intensive, we examined how EPSCoR states did on the two measures of retention compared to non-EPSCoR states. This analysis indicates that while the EPSCoR states have a somewhat lower level of retention, it did not reach an acceptable level of statistical inference (i.e., the results are not statistically significant). This suggested that there is no simple relationship between EPSCoR status and retention.

We also examined differences between member states of the Southern Technology Council versus states across the rest of the country, but found no statistically significant differences between the two groups of states. This suggests a heterogeneity of retention performance across the country, and no simple relationship to region.

These comparative analyses are interesting in themselves for their *lack* of a simple explanation of the retention of science and engineering graduates. Retention is not simply a regional phenomenon nor a function of a single characteristic of a state, such as its R&D capacity. The relationship is much more complex and argues for pursuing a more definitive predictive analysis such as that below.

Descriptive Results—Migration. As described above, there are two benchmarking measures for migration: (1) *Net Migration/Most Recent Degree*; and (2) *Net Migration/High School*. The basic descriptive results are displayed in *Figures 3* and *4*.

As with the results on state retention data, there are remarkable disparities across states in their net migration patterns. Consistent with how these metrics were computed, the mean of both *Net Migration/Most Recent Degree* and *Net Migration/High School* hovers around a value of 1. This, in effect, indicates a balanced migration (i.e., the "average" state loses about as many of its own graduates as it attracts from elsewhere). A look at the range of migration values in *Figures 3* and *4* also shows that the top states have migration scores two-to-three times larger than those in the lowest group of states. The two migration indices also have quite different rank orderings of the states. Several states in the top quartile of the *Net Migration/Most Recent Degree* index fall to the third or fourth quartile of the *Net Migration/High School* index (e.g., New Jersey and New Hampshire).

As with retention, analyses were performed comparing EPSCoR states versus non-EPSCoR states and Southern Technology Council (STC) member states versus non-STC states. Only one statistically significant difference was uncovered. In the comparison of EPSCoR and non-EPSCoR states on *Net Migration/High School*, EPSCoR states have slightly lower scores.[37] In effect, EPSCoR states' high schools are producing future scientists and engineers who eventually secure employment in non-EPSCoR states. In the predictive analyses below, we shed more light on the differences across states in migration patterns.

Commentary and Interpretation—Descriptive Results on Retention and Migration. The most obvious conclusions that can be drawn from the descriptive analyses are: (1) there are large disparities across states in retention and migration; (2) these differences do not seem to be a simple function of region or gross categorizations of states; and (3) the outcome indices on retention and migration are not highly correlated and appear to be tapping into qualitatively distinct phenomena.

There is one additional pattern of results worth noting. Looking at *Figures 1-4*, it appears that a few states do reasonably well on both the retention and migration outcomes. For example, three states (California, Hawaii, and Texas) are in the top quartile of performance on three of the four measures, and in the second quartile on the other. In fact, eight other states (Colorado, Georgia, Illinois, Louisiana, Oregon, South Carolina, Tennessee, and Washington) are in the top two quartiles of performance on all of the retention and migration outcomes. If one assumes that these metrics are a reasonable proxy for capturing science and engineering "human capital," then these 11 states seem to be at an advantage relative to their peers.

Results: Predictive Analyses

The ***predictive analyses*** identify which specific variables from the six general categories—geographic characteristics; industrial structure; state economic performance; federal spending; R&D/technology intensity; and policy variable—*predict* the in-state retention and interstate migration of recent science and engineering graduates. The objective was to identify the smallest group of variables that could statistically indicate between-state differences in retention and migration indices.

To achieve this objective, we pursued an exploratory predictive strategy involving several steps. First, correlations between each specific predictor variable and our retention and migration indices were computed and examined. Predictor variables that correlated with at least one retention or migration index at a level approaching statistical significance[38] were considered candidates for multiple regression analysis for that index.

Second, the list of predictor variables was refined by eliminating those that were statistically redundant.[39] Finally, all remaining significant predictors for each retention or migration index were included in a two-stage linear regression. Since geographic characteristics cannot be altered by a state, they were entered first. Then all other predictors were evaluated by a backwards stepwise regression until the solution was achieved.

1. Retention/Most Recent Degree

Analysis. The dependent (or outcome) variable predicted in this analysis, *Retention/Most Recent Degree*, is, in effect, the percentage of a state's college graduates retained in the state's workforce after graduation from college. Following the procedures described above, nine variables were initially selected as potential predictors on the basis of statistically significant correlations with *Retention/Most Recent Degree*. Of these, seven were retained for the multiple regression analysis.

The analysis shows that *Retention/Most Recent Degree* is primarily influenced by geographic factors such as (1) the total size of the state's workforce (favoring larger populous states) and (2) the absence of geographic patterns encouraging or permitting residents to work in bordering states. For example, smaller states that share urban boundaries with a number of other states tend to have "permeable" boundaries in terms of this measure. These two variables—the size of the workforce and the permeability of borders—explain 34 percent of the *Retention/Most Recent Degree* outcome. However, the retention of recent college graduates is also influenced by other variables, including (3) the percentage of high school students attending college in-state is the most important, followed by (4) a state's per capita income. These four predictors—size of the workforce, permeability of borders, percentage of students attending in-state colleges, and per capita income—ultimately explain 51 percent of the variance in the *Retention/Most Recent Degree* outcome variable.

Some intuitive understanding of these predictive results can be gleaned by looking again at *Figure 1*—the descriptive data on *Retention/Most Recent Degree*. Within the top quartile are several "nation states," states that are large in population (e.g., Texas and California) or states with relatively impermeable boundaries (e.g., Hawaii and Puerto Rico). There are also several high-wage states among the top quartile (e.g., California, Hawaii, Illinois, Massachusetts, and Michigan) and relatively fewer among the bottom quartile. Interestingly, a state's industrial structure, R&D intensity, and federal investments appear to have little or no impact on a state's ability to retain recent science and engineering graduates, at least as illustrated by this analysis.

2. Retention/High School

Analysis. The dependent (or outcome variable) for this analysis is *Retention/High School*. This was computed by dividing the number of respondents who both received their high school diploma in the target state and were working in that state at follow-up by the number who received their high school diploma in the target state and who were working in any state. Following our analytic strategy, we identified seven potential predictor variables that had statistically significant correlations with *Retention/High School*. Of these, we retained five for multiple regression analysis.

The outcome variable *Retention/High School* is determined by factors similar to those involved in the prediction of *Retention/Most Recent Degree*. That is, it is determined by geographic variables, particularly: (1) the total size of a state's workforce (favoring large populous states) and (2) the absence of geographic patterns encouraging residents to work in bordering states. These two variables alone explain over 45 percent of the outcome index. Obviously, however, states can do little about these factors. *Retention/High School* is also predicted by: (3) the percentage of students attending college in-state, (4) a state's income per capita, and (5) the percentage of a state's workforce involved in the wholesale sector. In the final solution, these five predictors explained 78 percent of the variance in the outcome variable.

Inspection of the states in the top and bottom quartiles, in this case in *Figure 2*, provides some intuitive confirmation of this pattern of predictive results. Once again, geographic factors such as being from a large state with relatively "impermeable" boundaries makes a difference. High-wage states also appear to have an advantage in retaining their own high school graduates going on to obtain science and engineering college degrees. Finally, states that successfully induce their high school graduates to attend college in-state also benefit. Interestingly, federal investments have little or no impact on the *Retention/High School* index. The wholesale sector finding is somewhat puzzling, but increasingly, companies in this industry are using advanced information and communications systems as an integral component of their business operations, and this may be contributing to this result.

Commentary and Interpretation—Predictive Results on Retention. With a few exceptions, there is a fair amount of consistency across the predictive results for *Retention/Most Recent Degree* and *Retention/High School*. From a public policy perspective, most of the predictors are givens and not subject to easy changes. States, for example, cannot change their borders through any simple means. Similarly, it is difficult to change the income structure of a state by fiat. There is a potential for changing the fraction of high school graduates who stay on to attend college in-state, and more detailed analysis is probably needed of the various policy and program options within this area.

3. Net Migration/Most Recent Degree

The dependent (or outcome) variable for this analysis is *Net Migration/Recent College Graduates*, and it is computed as the ratio of science and engineering college graduates (from any state) now employed in the target state compared to the number of college graduates produced by that state (and working in any state). Five variables were initially identified as candidate predictors based on their statistically significant correlations with the outcome variable. Of these, four were retained for the multiple regression analysis.

There appears to be minimal overlap between those variables predicting retention (e.g., the size of the workforce, permeable borders, etc.) and those predicting *Net Migration/Most Recent Degree*. In fact, geographic factors appear to play no role in predicting migration. The most powerful predictor[40] is (1) the percentage of students remaining in-state for college after high school, which, surprisingly, is negatively related. That is, the more in-state high schoolers stay home for college, the *less* likely is the state to experience positive net migration. This is followed by: (2) the percentage of gross state product (GSP) derived from service employment and (3) the average cost of out-of-state tuition at public higher education institutions. This latter predictor was also negatively related, suggesting that *lower* out-of-state public tuition yields *higher* net migration. These three variables ultimately account for 41 percent of the variance in this outcome.

4. Net Migration/High School

The dependent (or outcome) variable predicated in this analysis is *Net Migration/High School*. This is computed by dividing the number of respondents who received their high school degree in any state but who were employed in the target state at follow-up by the number who received their high school diploma in the target state and who were working in any state. Initially, seven variables were identified as predictors since they had statistically significant correlations with *Net Migration/High School*. Of these, five were retained for the multiple regression analysis.

Of the five variables, the most important predictor is: (1) the average cost of in-state tuition for public higher education. That is, *lower* in-state public tuition predicts *higher* net migration. Two geographic variables explain a relatively small (16 percent) portion of the outcome variance: (2) total state employment and (3) the absence of geographic patterns encouraging or permitting residents to work in bordering states (border "permeability"). The latter is a negative predictor in the sense that the *less* out-of-state work occurring, the higher is the net migration of science and engineering graduates. Other important factors include: (4) average technology wages and (5) federal defense funding per capita. The multiple regression procedure involving these five predictors ultimately explains 52 percent of the outcome variance in *Net Migration/High School*.

Commentary and Interpretation—Predictive Results on Net Migration. The predictive analyses performed on the two indices of migration—*Net Migration/Most Recent Degree* and *Net Migration/High School* respectively—yielded results that had many commonalties, as well as a few interesting differences.

Regarding *Net Migration/Most Recent Degree*, some of the relationships are relatively easy to interpret. For instance, in terms of GSP derived from service employment, it seems likely that states with large service sectors probably have the capacity to add technology workers, as the nature of service jobs becomes more attuned to the nature of the new global economy (e.g., banking via telecommunications). Likewise, lower out-of-state tuition may serve as an inducement to in-migration—a finding of significant policy relevance. Perhaps out-of-state students are attracted to a university system partially on the basis of the fee structure and then build personal and business relationships that are difficult to leave after graduation. This supposition needs more analysis, particularly some qualitative anthropological studies, that can better describe the after-graduation decision paths of students.

What is less clear is why there is a negative relationship between the percentage of high school students attending college in-state and *Net Migration/Most Recent Degree*. There are several plausible scenarios consistent with these findings. For example, this may simply reflect a situation where a state has a somewhat overbuilt science and engineering degree capacity that is also attractive to students from other states and an economy that is growing fast enough to absorb these students after they graduate. Also consistent with the data are situations in which a state produces a relatively large number of *future* science and engineering majors in its high schools but has a limited capacity to accommodate those majors in its colleges. They would have to go elsewhere to get educated.

Paradoxically, that same state's *Net Migration/Most Recent Degree* index might appear large, simply because it educated so few science and engineering majors in its colleges. At bottom, these relationships reflect the degree of "alignment" between three components: (1) the supply of high school graduates interested in science and engineering careers; (2) the capacity of a state's colleges and universities to provide education in those areas; and (3) the technology-oriented opportunity structure in a state's economy. Unfortunately, our data did not permit us to address this issue in more detail.

In contrast to the results discussed above, the predictive results on *Net Migration/High School* pulled in geographic variables, such as border permeability, as well as some interesting policy-relevant variables. Again, lower college tuition—in this case lower in-state tuition rather than out-of-state tuition—seems to attract science and engineering graduates from other states. This has, as noted above, interesting implications for legislators and university officials alike.

While it may be intuitively obvious to most that high wages and more jobs in technology-intensive companies would function as attractions to out-of-state science and engineering graduates, as the predictive results on *Net Migration/High School* suggest, some states seem to be less involved than others in this type of effort to build a technology-based economy. The data also provide some support for the positive role that federal facilities may play in the migration of science and technology personnel. What is not clear from our data, however, is the extent to which those individuals attached to federal facilities eventually migrate into the private sector, although some of the published literature suggests that this does occur.[41]

The most intriguing single finding in the analyses conducted of migration is that of the relationship between tuition levels and positive net migration. Clearly, it is in the power of legislators, taxpayers, and institutional officials to think through the trade-off between the pluses of tuition-derived revenue for colleges and universities versus the potential to use tuition levels as an important tool in a revised state economic development strategy—that is, one that is based on enhancing the science and engineering *human capital* that is available in a state.

Staying Home to Attend College: Its Role in Employment Retention and Migration

"Staying home" to attend college played a surprisingly strong predictive role in several analyses. Accordingly, we conducted a separate correlational analysis to identify predictors of this apparently critical decision event. Essentially, we came up with two geographic variables and a policy variable. The first variable is total state employment. The second, the percentage of state residents employed outside the state, is a negative predictor. In other words, the less interstate commuting, the more likely students will attend college in their home state. Obviously, neither of these predictors is actionable in a policy sense. The third variable—level of in-state tuition—was negatively related. That is, the lower in-state tuition, the more likely high school graduates will stay home to attend college. This last variable is obviously subject to change at either a state or institutional level. More detailed research needs to be performed on this topic.

Conclusions and Recommendations

Introduction

This analysis was launched because of Southern Technology Council concerns about emerging shortfalls in technology labor pools in the South. The movement of science and engineering talent is clearly a significant issue in terms of global economic competition. At a national level, the U.S. is a net importer (or retainer) of science and engineering personnel from other parts of the world, many of whom are trained in this country. For example, a relatively stable fraction of foreign nationals who receive advanced science and engineering degrees from U.S. universities stay on to work,[42] which has produced a human resource windfall for the U.S. over the years. There are analogous domestic movements of highly skilled individuals across state lines, and it was felt there would be some merit in examining the interstate migration patterns of entry-level science and engineering personnel as one component of that larger problem.

This analysis is a first, somewhat limited, attempt to address the issue of interstate migration. There are several limitations to the data reported, which should be noted. For one, this analysis did not include Ph.D.-level personnel. Second, because the NSRCG database was not constructed with state-level indicators in mind, there is some slippage in the precision of the state indices. Third, as a preliminary study, the predictive analysis was confined to fairly gross economic and policy variables. Fourth, the analysis would be more useful if longitudinal trends could be considered.

These qualifications notwithstanding, a number of important conclusions can be reached. These conclusions have significant implications for both public policy and institutional practices. Several broad conclusions and associated recommendations for action or further analysis follow.

Conclusion: State-by-State Disparities Are Large and Important

We were struck by the magnitude of differences, in both retention and migration, between those states in the bottom versus top quartiles of performance. Virtually every recent survey of business needs highlights the importance of a skilled workforce, and a difference of a percentage point on these indices can represent hundreds or thousands of people. Yet, prior to our analysis, important measures of a state's human resources have not been accessible to policymakers and have been discussed in terms of impressions and apprehensions.

Recommendations:

1. Universities, through their institutional research functions, should gather data on an ongoing basis on the employment and geographic status of graduates, by both discipline and type of degree. In addition, universities in a region (or nationally) should agree to a standardized approach to such data collection to enable comparative benchmarking analyses.

2. State economic development organizations should use retention and migration patterns as both important performance metrics and a focus of programmatic activities. In effect, economic development organizations should be focused on attracting and retaining *human capital* with a similar enthusiasm as is now devoted to attracting and retaining state businesses (e.g., recruitment incentives for people, as well as com-

panies). For example, the Oklahoma Department of Commerce has developed a database of recent Master's and Ph.D. graduates from state institutions, and it is distributed to companies in the state.[43] The private sector-led Da Vinci initiative in New York is trying to "repatriate" state-based university graduates who have left the area to return to fill job openings in technology-based companies. Da Vinci has acquired lists of graduates, worked through parents, and devised a variety of tactics to reach this population.[44]

Conclusion: States Can Only Influence Retention at the Margins

Concerns about sons and daughters being able to secure good jobs close to home can have an enormous emotional pull on state residents and a powerful political impact. However, our analyses suggest that most of the variance in a state's ability to retain its own science and engineering college graduates is determined by geographic factors, such as size and relative isolation from other labor markets, that are outside a state's control. In turn, these factors also appear to explain most of the variance in the third predictor—staying home to attend college. The only predictor of retention that can be remotely influenced by policymakers is income per capita. As we discuss below, this variable is also related to a state having a technology-based, high-skill economy, which is a long term proposition indeed.

Recommendation:

1. States need to focus on addressing those factors which will encourage high school graduates to attend college in-state, as well as those factors which will attract both external graduates and home grown talent to seek employment in their state.

Conclusion: The New Economy is an Important Ingredient

Many of the predicted results point to the importance of the "new economy" as being a powerful magnet for migration. That is, state economies that are high value-added, service-oriented, more R&D-intensive, and are paying high wages for high skills are able to retain and/or attract more science and engineering graduates.

Recommendations:

1. States should intensify their efforts to build 21st century economies that emphasize technology-based entrepreneurial companies, international trade, and a highly skilled workforce. Those states that do not and that continue to invest significant tax revenues in their state universities will be functioning as a "farm team" for other states. States should not be content to have their major export be their brightest young people.

2. More state decisionmakers—particularly legislators, economic development officials, and educators—need to better understand the workings of the new global economy. This includes developing a better understanding of how it relates to opportunities for young people. Additionally, regional and national groups need to devote more attention to economic education outreach and leadership development.

Conclusion: Tuition Levels Matter

One of the more surprising findings is the relationship between in-state and out-of-state tuition levels and net migration. Our data strongly suggests that the higher these fees are, the less likely a state is to function as a magnet for the best and brightest in science and engineering. There is, of course, a long and tortured political history behind the current pattern of tuition. Over the past 10-15 years, a number of states severely tightened their budgets, resulting in flattened or declining appropriations for higher education. In response, universities became more "entrepreneurial"[45] and sought non-traditional research and technology partnerships with industry, and/or they increased tuition and fees. Since political realities usually precluded raising in-state fees too high, a pattern of out-of-state students paying significantly higher tuitions developed. Few of these tuition decisions were informed by economic development considerations. Our data strongly suggests that this policy issue needs to be revisited. Moreover, the relationship between tuition levels and retention/migration may have influence at the Ph.D. level of training in science and engineering as well, and this warrants research.

Recommendations:

1. States seeking an economic advantage should seriously consider stabilizing or lowering both in-state and out-of-state general tuition levels.[46]

2. State economic development organizations should collaborate with state universities to target key science and engineering disciplines—particularly ones that match the needs of the state's economy—and deliver financial assistance to the best and brightest students.

3. It would seem that state-based corporations and state economic development organizations should have a mutual interest in sweetening the decision environment in which recent science and engineering graduates decide where to work. We recommend that a best practice analysis be undertaken on alternative approaches thereto. For example, what symbolic or tangible incentives, or special outreach activities, are being used to "land" graduates of state institutions and/or lure the graduates from other states?

4. This study did not examine the paths by which science and engineering graduates decide upon employment. In parallel with the above best practice analysis, it might be useful to conduct a series of anthropological case studies—from the perspective of students—on the transition to employment of science and engineering graduates.

Conclusion: Stayers Stay

The study results seem to indicate a geographic inertia that states can manipulate to their advantage with appropriate policies. That is, if high school graduates stay in their home state for college (and perhaps graduate school), they are more likely to seek employment in their home state as well. This suggests that states emphasizing a "repatriation" strategy directed at recent science and engineering graduates may be ignoring more cost-effective strategies. It seems wiser for states to make it as easy and as desirable as possible for their best graduates to stay in-state for college. "Keeping it home" is perhaps easier than bringing it back.

Recommendations:

1. States and universities should devote more effort and resources to keeping their best and brightest high school graduates in state-based institutions. This could involve rethinking and restructuring tuition policies (see above), more scholarship resources, and a more focused and aggressive outreach to better students in the state. In fact, as reported in a recent issue of the *Chronicle of Higher Education*,[47] governors, legislators, college presidents, and private sector groups in at least a dozen states are debating or implementing such approaches. However, the article goes on to suggest that there is not good information about how states stack up relative to one another on the "brain drain" problem, and that "little is known about the causes and effects" thereof. We trust that this Southern Technology Council report will shed some empirical light on all of these issues.

Appendix A: Computational Formulas for Outcome Variables[48]

Retention/Most Recent Degree (R/MRD):

$$\text{R/MRD} = \frac{\text{Number of recent college graduates from state A working in state A}}{\text{Number of recent college graduates from state A working in any state}}$$

Retention/High School (R/HS):

$$\text{R/HS} = \frac{\text{Number of recent college graduates who received their high school degree from state A working in state A}}{\text{Number of recent college graduates who received their high school degree from state A working in any state}}$$

Net Migration/Most Recent Degree (NM/MRD):

$$\text{NM/MRD} = \frac{\text{Number of recent college graduates from any state working in state A}}{\text{Number of recent college graduates from state A working in any state}}$$

Net Migration/High School (NM/HS):

$$\text{NM/HS} = \frac{\text{Number of recent college graduates who received their high school degree from any state working in state A}}{\text{Number of recent college graduates who received their high school degree in state A working in any state}}$$

Appendix B: Predictive Variables

Geographic Characteristics:

- Total state employment
- Percentage of state residents employed in other states (border “permeability”)

Industrial Structure:

- Percentage of a state’s workforce employed in each of the following sectors:
  — Agriculture
  — Manufacturing
  — Wholesale
  — Service
  — Government

State Economic Performance:

- Income per capita
- Percentage unemployed
- Gross state product per capita

Federal Funding:

- Federal defense spending per capita
- Federal non-defense spending per capita

R&D/Technology Intensity:

- Percentage of state workforce employed in technology
- Percentage of state establishments that are technology-based
- Industry R&D spending per capita
- Academic R&D spending per capita
- Patents awarded per capita
- Small Business Innovation Research (SBIR) grants awarded per capita
- Average technology wages
- Percentage change in technology employment

State Education Investments and Policy Variables:

- State support of science and technology initiatives per capita
- Support for higher education per capita
- Annual cost of in-state public college tuition
- Annual cost of out-of-state public college tuition
- Fraction of high school students who attend high school and college in the same state (“stayers”)

Endnotes

[1] This effort is supported on an ongoing basis by the National Science Foundation (NSF). Our thanks to the Division of Science Resources Studies of NSF for their cooperation in making this database available for researchers.

[2] *The Global Context for U.S. Technology Policy.* Office of Technology Policy, Technology Administration, U.S. Department of Commerce, Washington, DC, 1997.

[3] National Academy of Engineering. *Risk and Innovation. The Role and Importance of Small High-Tech Companies in the U.S. Economy*. Washington, DC: National Academy Press, 1995.

[4] American Electronics Association, *Cyberstates. A State-by-State Overview of the High Technology Industry*. Washington, DC: American Electronics Association, 1997.

[5] National Science Foundation. *Science and Engineering State Profiles, Fall 1996*. NSF 97-306. Arlington, VA: National Science Foundation, 1997.

[6] Tornatzky, L.G., Waugaman, P.G., and Bauman, J.S. *Benchmarking University-Industry Technology Transfer in the South: 1995-1996 Data*. Research Triangle Park, NC, Southern Technology Council, 1997.

[7] Tornatzky, L.G., Batts, Y., McCrea, N.E., Lewis, M., and Quittman, L.M. *The Art and Craft of Technology Business Incubation. Best Practices, Strategies, and Tools from More than 50 Programs.* Research Triangle Park, NC, Southern Technology Council, 1996.

[8] Casson, L., Bauman, J., Fisher, E.R., Lindblad, M., Sumpter, J.R. , Tornatzky, L.G., and Vickery, B.V. *Making Technology Happen. Best Practices and Policies from Exemplary K-12 Schools*. Research Triangle Park, NC, Southern Technology Council, 1997.

[9] Snyder, T., Hoffman, C., and Geddes, C. *National Center for Education Statistics: Digest of Education Statistics 1996.* Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, 1997.

[10] BankBoston. *MIT: The Impact of Innovation*. Boston, MA: BankBoston Economics Department Special Report, 1997.

[11] Interestingly, way down the list, in terms of importance, were issues such as favorable tax or regulatory environments. This illustrates how the technology-based economy responds to a different set of factors than does traditional industry.

[12] For a discussion of this critical national problem see: Office of Technology Policy. *Americas New Deficit: The Shortage of Information Technology Workers*. Washington, DC: U.S. Department of Commerce, 1997.

[13] See, for example: MDC, Inc. *The State of the South*. Chapel Hill, NC: MDC, Inc., 1996.

[14] Campbell, S. "Inner-regional migration of defense scientists and engineers to the gun belt during the 1980's." *Economic Geography*, Volume 69, No. 2, 1993, pp. 204-223.

[15] Bannia, N., Calkins, L.N., and Dalenberg, D.R. "The Effects of Regional Science and Technology Policy on the Geographic Distribution of Industrial R&D Laboratories." *Journal of Regional Science*, Volume 32, No. 2, 1992, pp. 209-228.

[16] Kyung, W. "In-Migration of College Students to the State of New York." *Journal of Higher Education*, Vol. 67, No. 3, 1996, pp. 349-358.

[17] Morgan, J.N. "Tuition Policy and the Interstate Migration of College Students." *Research in Higher Education*, 19, 1983, pp. 183-195.

[18] Angel, D. "The labor market for engineers in the U.S. semiconductor industry." *Economic Geography*, Vol. 65, No. 2, 1989, pp. 99-112.

[19] Lehnen, R.G. and McGregor, E. "Human capital report cards for American states." *Policy Sciences*, 127, 1994, pp. 19-36.

[20] Tornatzky, L.G., Waugaman, P.G., and Casson, L. *Benchmarking University-Industry Technology Transfer in the South: 1993-94 Data*. Research Triangle Park, NC, Southern Technology Council, 1995.

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

[22] Of the 25,785 in the original sample, 86% responded, 9% were not located, 4% refused, and 2% did not respond within the data collection period. An additional 2,670 were identified as ineligible.

[23] It should be noted that this 1991-1992 time frame immediately preceded the major economic expansion that has occurred over the past five years. This may limit the ability to generalize our findings.

[24] A more detailed description of the weighting scheme can be found in: National Science Foundation and Westat, Inc. *1993 National Survey of Recent College Graduates: Methodology Report*. Washington, DC: National Science Foundation, Division of Science Resource Studies, November, 1995.

[25] Input from the NSRCG indicated that this weighting approach yielded unbiased estimates of national population values and would also be the most appropriate approach for getting to state-level estimates.

[26] For a copy of the questionnaire, see National Science Foundation and Westat, Inc. *Op Cit*, 1995.

[27] Early in the project, it was hoped that comparative analyses could be performed on the basis of the types of institutions graduates had attended (e.g., Land Grant research universities versus private institutions). However, this did not prove feasible because of sample size considerations at the institutional level.

[28] Since this is primarily a study of the geography of employment after college graduation, an additional variable was also created—the "status" of each respondent. If, during the reference week, respondents were working full-time, or working part-time but not in school, they were classified as "employed." If respondents were not working at all, they were classified as "unemployed." If respondents were full-time students working part-time or not working at all, then they were classified as a "student". If respondents indicated they were in school part-time and working part-time, they were classified as "employed" unless they indicated they were employed part-time because they were students (e.g., as graduate assistants, interns, etc.). In that case, they were classified as a "student".

[29] Alaska and the District of Columbia were eliminated from the data set. Both had a small sample of respondents. Data for a variety of predictive variables were not available for Puerto Rico, so it was eliminated from the predictive analyses.

[30] As alluded to above, the stratified probability sample used for National Survey of Recent College Graduates (NSRCG) was designed to provide accurate *national* estimates about recent college graduates in science and engineering fields. However, it should be noted that the sample was not stratified by *state*. As a result, there is some built-in imprecision in the computation of the Benchmarking Indices just described, and which in turn are presented (*Figures 1-4*) and discussed. For example, depending on the sample of students drawn in any given state for NSRCG, our computed Benchmarking Index (e.g., *Net Migration/Most Recent Degree*) may have a small or large expected variation around the "true" value that might have been computed on the basis of a more representative sample of observations for that state. Without going into statistical nuances, the practical implication is that our placement of states into levels of performance on the Benchmarking Indices (see *Figures 1-4*) should not be assumed to be perfect for any given state on a particular index. Nonetheless, for most of the states most of the time, the indices are very good indeed. Readers should examine where their state is ranked on all of the Benchmarking Indices, and try to get a composite picture. In addition, interested parties are invited to contact the research team directly to discuss these issues and the data for their states.

[31] Details on the computation or the database from which the specific predictor variables were extracted are available from the research team.

[32] The Experimental Program to Stimulate Competitive Research (EPSCoR) is a 20-year National Science Foundation program to focus attention on those states in the bottom tier nationally in terms of R&D performance. There are nineteen EPSCoR states, of which nine are members of the Southern Technology Council (Arkansas, Alabama, Kentucky, Louisiana, Mississippi, Oklahoma, Puerto Rico, South Carolina, and West Virginia).

[33] As described above, the sampling approach employed by the NSRCG and our computation of state-level indices raises some questions about whether the resultant retention and migration measures are sufficiently precise to allow for one-to-one comparisons of states. The research team concluded that a conservative approach would be to refrain from reporting state-specific values of the retention and migration indices, except when citing illustrative states in the text. Accordingly, we have grouped states in quartiles in *Figures 1-4* when presenting the various benchmarking comparisons.

[34] 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.

[35] The terms "statistical significance" and "statistically significant" are used throughout this report. They refer to the probability level that an observed statistical result could have occurred simply by chance. For example, a result with a probability (p) value of $<.10$ indicates that the chances are less than one in 10 that the result could have occurred randomly. Similarly, a p value of $<.05$ indicates a less than one in 20 probability that the result could have occurred by chance.

[36] Again for the statistically uninitiated, the basic logic of multiple regression analysis extends correlational analysis to the problem of predicting an outcome (a *dependent* variable) on the basis of several *predictor* (or *independent*) variables. In addition, the analysis is able to sort out which predictors are the most powerful in terms of understanding the dependent variable. For example, suppose we wanted to predict the business performance in average annual sales growth (dependent variable) of a technology firm based on the percentage of scientists in its workforce, patents held per scientist, and research spending as a fraction of sales (independent variables). If we had numerical data on all these variables for 100 companies, this would be an easy multiple regression problem to solve.

[37] $p <.05$.

[38] $p < .10$ in this case.

[39] In multiple regression analysis, high correlations among predictors causes a development called multi-collinearity and yields results that are unstable and difficult to interpret. Since most problems with multi-collinearity are attributable to variables that are tapping into the same underlying phenomenon, one of any two highly correlated predictors (r =.55 or greater) was dropped from further analyses.

[40] The relative importance of predictors was determined by examining their standardized *beta* weights in the multiple regression results.

[41] Campbell, S. *Op Ci*t, 1993.

[42] Finn, M., Pennington, L., and Anderson, K. "Foreign Nationals Who Receive Science or Engineering Ph.D.s from U.S. Universities: Stay Rates and Characteristics of Stayers." Unpublished paper, Oak Ridge Institute for Science and Education, April, 1995.

[43] "Keep 'em home," *The Wall Street Journal*, January 6, 1998.

[44] The reader is invited to tour their Internet Website: davincitimes.org

[45] Slaughter, S. and Leslie, L. *Academic Capitalism: Politics, Policies, and the Entrepreneurial University*. Baltimore: The Johns Hopkins University Press, 1997.

[46] One chancellor of a major research university in the South has made an impassioned public argument to that effect. See Monteith, L. "Point of View—North Carolina's Brain Drain." Raleigh *News and Observer*, April 1, 1997.

[47] Schmidt, P. "More States Try to Stanch 'Brain Drains,' but Some Experts Question the Strategy." *The Chronicle of Higher Education*, February 20, 1998.

[48] All data entered into these formulas are weighted using procedures developed by the creators of the NSRCG database.