

1998

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Recommended Citation

Tornatzky, Louis G. , Denis Gray, Stephanie A. Tarant, and Julie Howe. "Maine's Science and Engineering Brain Drain: How Much and Why?." *Maine Policy Review* 7.1 (1998) : 44 -49, <https://digitalcommons.library.umaine.edu/mpr/vol7/iss1/5>.

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Maine's Science and Engineering Brain Drain How Much and Why?

Maine Policy Review (1998). Volume 7, Number 1

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More than the traditional economic ingredients, the new global economy is being built around talented people with special knowledge and skills - people with the capacity to innovate and with the entrepreneurial wherewithal to turn ideas into commercial products. Hence many states are shifting their economic development strategies away from efforts that market commodities like low tax rates and cheap labor, and toward efforts that amass and equip talented people with the tools of innovation. In short, states are beginning to think about strategies for recruiting and/or retaining talented workers. In this regard, the Southern Technology Council conducted a national study to compare states on their performance in retaining their own recent science and engineering graduates and/or attracting similar graduates from states elsewhere in the country. "How is Maine doing?" they ask. In a word, poorly. The authors compare Maine to other states on a number of performance indicators and predictor variables to assess why this is so. They suggest Maine take bold steps now to prevent the continued loss of its most important commodity of the future.

It is now generally conceded that the current economic environment is qualitatively different from that which prevailed little more than a decade ago. That is, we are in the midst of a "new economy" that is characterized by burgeoning trade and global business relationships, the importance of technology in new products and processes, a key role of small entrepreneurial companies, and the particular importance of a skilled and educated workforce. To illustrate, the American Electronics Association (1998) reports that as of 1996, the U.S. high-technology industry was the largest in the country, paid an average wage that was 73% higher than the average private sector wage, and was exporting over \$150 billion in goods, making it the largest United States exporting industry.

Regarding the workforce issue, it should not be too surprising that a knowledge-based economy is heavily reliant on people with scientific and technical expertise. Recent analyses have suggested that some fast-growing industries are being stymied by a lack of new hires with appropriate skills (Office of Technology Policy, 1997), and human resources are typically at the top of most companies' list of pressing business issues. There is also longitudinal evidence that highly skilled people not only play an important role as new hires, but also as a wellspring of entrepreneurial start-up companies. For example, the record of MIT graduates is startling. They have founded over 4,000 firms, employing 1.1 million people, and generating \$232 billion in sales (BankBoston, 1997).

These issues are increasingly the focus of public policy debate as well, as political and economic development leaders see human resources as an important ingredient in a state's long-term growth strategy. For example, in a recent issue of *Maine Policy Review*, David Silvernail (1997) examined the issue of Maine residents' participation in higher education. When compared against a number of similar states, Maine seems to fair poorly on a number of participatory indices.

However, from an economic development perspective, a more telling analysis might focus on the participation of individuals as working members of the economy with key technical skills (e.g., individuals with recent science and engineering degrees). After all, the new economy is being built around talented people with special knowledge, more than the traditional economic ingredients.

Recently the Southern Technology Council conducted a national analysis of interstate migration of recent science and engineering graduates. Using a database developed through the National Survey of Recent College Graduates (NSRCG), the Southern Technology Council team was able to analyze a national sample of individuals who were currently working, and who had recently received either a bachelor or master's degree in a science or engineering discipline. The thrust of the Southern Technology Council analysis was to compare states on their performance in retaining their own recent science and engineering graduates and/or attracting the graduates from states elsewhere in the country. In effect, some states can be net exporters of science and engineering personnel, while others may function as magnets for this important human commodity. In addition, the Southern Technology Council team conducted predictive analyses in a preliminary attempt to determine key factors that seemed to influence interstate personnel migration phenomena.

BENCHMARKING RETENTION AND MIGRATION OF RECENT SCIENCE AND ENGINEERING GRADUATES

Although there has been considerable interest in and debate about a so-called "brain drain" within state governments (Schmidt, 1998), few states or even institutions systematically monitor retention or migration rates. Further, lack of any standardized measure of these phenomena preclude state-by-state comparisons for those that do. By taking advantage of the NSRCG, a national probability survey of recent science and engineering graduates supported by the National Science Foundation, the Southern Technology Council team was able to produce retention and migration benchmarking data for the whole United States.

Data analyses were based on the 1993 NSRCG database, the most recent available at the time. NSRCG-93 includes personal, educational and employment data on over 19,000 science and engineering students who received their degrees sometime between spring 1990 and 1992. Employment data for these individuals focused on their status for the "target week," April 15, 1993.

Without going into the methodological and computational detail of the Southern Technology Council study, suffice it to say that four "outcome" indices were developed using the raw data from the NSRCG database. Two outcome indices focused on retention, although based on different graduation cohorts. In one case, the analysis looked at the extent to which individuals

who had received a high school degree in a focal state (and who had then gone on to get a bachelor and/or master's degree in science and engineering anywhere) are now working in that state's economy. A parallel index computed the fraction of recent science and engineering graduates (at either the bachelor or master's level) from a focal state's colleges and universities who are now working in that focal state's economy

In addition, two outcome indices were developed to capture the phenomena of net migration of science and engineering graduates. That is, whatever their retention performance for locally educated students, states can also reach a positive balance of trade in science and technology personnel by functioning as a magnet for individuals who were educated elsewhere and take a job within that state. By the same token, some states may be experiencing a negative net migration, not only because they are not retaining their own, but also because they are not attracting graduates from elsewhere. Net migration was computed by comparing the number of former students from any state who are working in the focal state compared to the number of graduates produced by that state's education system (high schools; recent college graduates). A fuller description of the calculation of these indexes is given in the original report (Tornatzky et al., 1998).

HOW IS MAINE DOING?

How is Maine doing? In a word, poorly. On the two retention performance indices described above, Maine is among the bottom five states. Perhaps more importantly, the retention percentages among the top ranked states are nearly four times those of Maine. Maine's standings on the migration indices are similarly disappointing; it is among the bottom five states in terms of both net migration measures. Further; the absolute values of the migration indices suggest that Maine has, in effect, a negative exchange balance with other states in terms of recently graduated science and engineering personnel. This is "brain drain" with a vengeance.

It's worth noting that the NSRCG focused on 1993, a period of economic slowdown and general population loss in Maine, and that observers have already noted young people were more likely to be outmigrants (Murphy, 1997). However; our analyses indicate that this exodus was particularly high among college-educated scientists and engineers the key ingredient in fueling growth in the new economy

FACTORS CONTRIBUTING TO RETENTION AND MIGRATION: NATIONAL AND MAINE DATA

As indicated above, the Southern Technology Council team devoted considerable effort to determine what factors seemed to predict or determine the retention or migration outcomes. Using census and other national databases, we developed a battery of state-level predictor variables from six domains.

Geographic characteristics (e.g., size and density of population) were used because these variables were seen as important in the literature and tend to be "givens" a state can do little to change. Variables that described industrial structure (e.g., percentage of GDP by sector) were included on the assumption that certain industries might be better employers of science and

engineering (S&E) graduates. State economic performance variables (e.g., income per capita) were included because a robust economy might be more attractive to graduates. Federal funding variables (e.g., funding for defense per capita) were used because some research indicates certain kinds of federal spending can support or stimulate S&E employment. R&D/technology intensity variables (e.g., industry R&D spending per capita) were examined because of the obvious link between research activity and investments, and S&E manpower. State education and policy variables (e.g., state support for science and technology initiatives per capita) were included based on the assumption that states can take actions to make their institutions and labor market more attractive to graduates. A complete list of predictor variables is provided in the full report (Tornatzky et. al., 1998).

The general analytic approach was multiple regression analysis. Statistically significant geographic predictors were "forced" into the equation first in order to control for their effects. Other predictors were added based on a stepwise inclusion criterion which identified the best predictors. In general, the predictive analyses were able to explain a great deal of the variance in state-level retention and migration. Four predictors explained 51% of the variance in retention/most recent graduates; five predictors were able to explain 78% of the variance in retention/high school graduates; three predictors explained 41% of the variance in net migration/most-recent graduates; and five predictors explained 52% of the variance in netmigration/most-recent graduates.

Of the factors that determined retention outcomes across fifty states, several seemed to have interesting implications for Maine. For example, one significant predictor of both retention measures was per capita income. It is worth noting that Maine ranks 35th in personal income per capita. Another prominent predictor was the percentage of high school graduates from Maine attending college in-state. In Maine's case, the state ranks 35th in the percentage of students attending both high school and college in-state. This theme was analyzed in significant detail by Silvernail, as noted above. Another factor negatively associated with retention across the fifty states was permeable borders. This was operationalized by the percentage of residents who are employed out of state. Looking at Maine's geography there is clearly a potential for cross-border employment-seeking in the technology-intensive industrial regions of Massachusetts and other proximal states.

Turning to the prediction of the net migration indices, there were again some interesting findings from the national analysis that seemed to have clear relevance for Maine. Perhaps most interesting was the negative relationship between public tuition levels (both in-state and out-of-state fees) and net migration. In other words, the lower that public tuition is, the higher the states net migration rates. While speculative, this is probably due to the tendency of graduates to seek employment close to where they earn their degree. Unfortunately, Maine ranks as the 13th highest state in terms of in-state public tuition and 19th highest in out-of-state tuition. Another predictor of net migration was average technology wages (lower wages yielded negative net migration), and on this measure Maine ranks 35th among the states. Finally, defense spending was positively associated with net migration, an area Maine has suffered some losses during the early 1990s.

CONCLUSIONS AND RECOMMENDATIONS

This geographic analysis of employment trends of recent science and engineering graduates strongly indicates that Maine has a problem. Not only is the state not retaining its own best and brightest, but it is failing to attract talented individuals from elsewhere in the country. In the long run, this has serious implications for economic development in the state. As the country moves toward embracing the new formula of technology, skills, and globalization, Maine will be increasingly at risk.

Based on the Southern Technology Council analysis of predictive factors involved in retention and migration, there appears to be several areas demanding further analysis and possible policy action:

- It seems relatively clear that Maine must increase the level of investment in and support of its public higher education system, particularly its flagship research university - tuition levels are non-competitive, the state is in the bottom quartile in terms of higher education expenditures per capita, and the R&D performance of its institutions lags the national leaders.
- However; if Maine does nothing more than beef up support of its higher education system, the likely result may be an acceleration of its export trade of bright people. There are simply too many technology-based jobs in proximal states, and lacking its own indigenous technology structure, Maine will continue to be a science and engineering farm team. The policy implication for the state is that it needs to devote significant effort and expenditures in building a technology-based economy. Moreover, there are only two ways to do this: One is to recruit technology-based companies from elsewhere. Paradoxically, having a large supply of science and engineering graduates who must leave the state to find suitable employment may turn out to be a distinct industrial recruitment advantage. Second, the state can grow its own technology-based companies through various entrepreneurial support programs, seed investment funds, and similar approaches. However, it must also ensure that there are incentives for keeping these enterprises and their jobs in Maine once they are created.
- Finally, Maine should embark on a significant and much more detailed analysis of retention and migration patterns of science and engineering personnel, and the factors which influence them. The data reported here are derived from a national database commissioned by the National Science Foundation. It would be worthwhile for Maine's state policy makers to address a similar set of issues through a much more robust Maine study sample, with data collected over a number of years. For instance, how has Maine fared in the hyper-competitive market for information technology workers? Would Maine expatriates have stayed home if comparable jobs were available locally? What factors have induced scientists and engineers trained in other states to migrate to Maine?

Clearly Maine has a significant challenge in amassing the highly skilled human resources that are critical to a knowledge-based economy. It cannot act too quickly.

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ENDNOTES:

1. Since this study was performed NSF has completed and disseminated results from the 1995 version of the NSRCG.
2. NSRCG defines scientists and engineers as anyone who receives a degree in the life, physical and social sciences, as well as in the engineering fields.
3. Because of the large number of predictors examined and the potential for multicollinearity, variables were accepted if they were significant at $p < .1$

Full cite: Tornatzky, Louis G., Denis Gray, Stephanie A. Tarant, and Julie Howe. 1998. *Maine's Science and Engineering Brain Drain.* Vol. 7(1): 44-49.