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GRADUATE EDUCATION, INNOVATION AND FEDERAL RESPONSIBILITY

by

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I. Introduction

The ancient Jewish scholar, Rabbi Hillel, is said to have been challenged by a disbeliever to teach him the whole Jewish Torah while standing on one foot. Rabbi Hillel is reputed to have replied "That which is hateful to you, do not do to your neighbor. That is the whole Torah; the rest is commentary"[1] My message to you today is not quite as succinct, but can be summarized in five points:

1. Research and development lead to innovation and economic growth.
2. Graduate students in general, and foreign graduate students in particular, play a major role in the production of research and innovation
3. Attempts to make statements about shortages of PhD level scientists and engineers are almost certainly doomed to fail and miss the point that what is optimal from the perspective of different actors in the market (individuals contemplating graduate study, individual professors, academic departments and employers), is not necessarily optimal for the nation as a whole
4. Financial stresses faced by American higher education institutions have very serious implications for the future flow of American college graduates into PhD programs and
5. The mobility of college graduates in general, and PhDs in particular, will cause states to under invest in their public higher education systems and provides a strong argument for an increased federal role in graduate education.

All that follows is an elaboration of these points and commentary.

[1] As quoted at http://www.mechon-mamre.org/jewfaq/sages.htm

II. Research and Development, Innovation and Economic Growth

A large and growing body of literature suggests that our nation's level of economic growth is related to the investments that we make in research and development. Some studies focus on the nation as a whole and ascertain the impact of research and development on productivity growth.[2] Others focus on local areas and study how innovative activity of firms in an area relates to the level of university research and development expenditures being conducted in the geographic area.[3] Still others have looked at productivity growth rates in manufacturing industries over time and concluded that these are related, with a lag, to the stock of research that has been done that relates to the industry.[4] The conclusion of all is that research in science and engineering plays an important role in economic growth.

III. The Role of Graduate Students

Graduate students have long been recognized as in important input into research and development activities, although only recently have attempts to quantify their importance been made. In an earlier paper and in research in progress, James Adams and his colleagues have used institutional-level panel data for over 100 major research universities and concluded that, other factors held constant, the research productivity of faculty members at an university, as measured by either publications or citations, is positively related to the stock of the university's PhD students.[5] Keith Maskus and his colleagues use national time-series data and similarly find that, holding other factors

[2] Basu, Fernald and Shapiro (2001), Basu, Fernald ,Oulton and Srinivasan (2003), Gordon (2004a, 2004b)
[3] Jaffe (1989), Anselin, Varga and Acs (1997, 2000), Feldman and Audretsch (1999)
[4] Adams (1990)
[5] Adams and Grilliches (1998) and Adams, Marsh and Clemmons (2005)

constant, an increase in the number of science and engineering PhDs is associated with increases in patent applications, university patents granted and non university patents granted.[6]

Some new PhDs in science and engineering move into academic positions, but many move into industrial positions. In each of these roles they become inputs into the production of new knowledge. The movement of PhDs in science and engineering into industrial positions is also a route via which knowledge is transferred from universities to industry.[7] Studies that have sought to quantify the importance of this route find this is a moderately important, but not the major, route via which knowledge flows from academia to industry occur and is very industry specific.[8]

Finally recent research has addressed the role that foreign graduate students play in innovation activities in the U.S. As background, concern is often expressed that foreign graduate students are displacing American graduate students in general, and under represented minority graduate students in particular, in PhD programs in the United States. However, the only study that I know of that looked at the preferences of American Universities for foreign graduate students found that a number of our nation's leading research universities "discriminated" against foreign students, in the sense that American citizen student applicants had a higher probability of being admitted to doctoral programs than did foreign applicants with the same admissions credentials (test scores).[9] If this is the case, one might expect that, on average, foreign PhD students are more highly qualified than domestic PhD students and they will, on average, contribute more to

[6] Chellaraj, Maskus and Matoo (2005)
[7] Sumell, Stephan and Adams (2003)
[8] Cohen, Nelson and Walsh (2002) and Agrawal and Henderson (2002)
[9] Attiyeh and Attiyeh (1997)

research and innovation. This is, in fact, the conclusion of Keith Maskus and his colleagues, who find that, other factors held constant, an increase in the share of foreign graduate students in total graduate enrollments is associated with increases in patent applications, university patents granted and non university patents granted.[10]

Other papers at this conference will discuss the changes in enrollments of foreign graduate students that have taken place in the United States in recent years and the factors that are responsible for these changes, including the increased difficulty of obtaining visas that resulted from the aftermath of 9/11, the sense by some foreigners that the U.S. is no longer a hospitable environment for them, and the growing strength of higher educational systems in other nations around the world. In 1990, former Harvard College Dean Henry Rosovsky asserted that "Fully two thirds to three quarters of the best universities in the world are in the United States".[11] A recent quantitative ranking of world universities conducted by the Institute of Higher Education at Shanghai Jiao Tong University, which was based on a faculty and alumni awards, citations and publications, concluded that 85% of the top 20 universities in the world in 2004 were in the United States.[12] However, the U.S share of the top 100 was only 51%.

It would be unwise for us to assume that our leadership in graduate education and research will persist in the future, absent our taking steps to strengthen our graduate programs. The mere fact that a Chinese university undertook this study suggests what the aspirations of that large nation are for its higher education system. Hence a continual flow of talented foreign students into U.S. science and engineering PhD programs and

[10] Chellaraj, Maskus, and Mattoo (2005)
[11] Henry Rosovsky (1990)
[12] See http://ed.sjtu.edu.cn/ranking.htm .

into postdoctoral research positions in the U.S in the future should not be taken for granted by us.

III. Shortages and the Financial Pressures Faced by Public Higher Education

The idea that shortages or surpluses exist in markets in which prices are free to adjust, such as the market for PhD scientists and engineers, is somewhat alien to economists, such as myself, because ultimately price changes will bring markets into equilibrium. Rather economists worry about the time that it takes markets to adjust; in situations in which there are long lags in the response of supply to price, such as in the production of PhD scientists and engineers. In these situations, public policies might be called for that facilitate adjustments to equilibrium, such as temporarily changing the number of government sponsored-assistantships, fellowships or traineeships provided for PhD students.

While there have been numerous attempts to forecast whether a shortage or surplus of PhDs will occur in the future, these have all been doomed to fail because of the adjustments that labor markets can make.[13] To take but one example, which I will return to below, financial pressures faced by American higher educational institutions, have led them to substitute cheaper part-time and full-time non tenure-track faculty for full-time tenured and tenure-track faculty in recent years; thereby rendering any forecast of the replacement demand for retiring tenure-track faculty inaccurate.[14]

The question of whether a shortage or surplus exists, is also often in the eyes of the beholder. From the perspective of PhD students and postdoctoral fellows seeking jobs, restrictions on the number of full-time tenure-track faculty positions at academic

[13] Ehrenberg (1991)
[14] Ehrenberg and Zhang (2005)

institutions looks a lot like a surplus situation. From the perspective of individual faculty members involved in the scientific enterprise, increased research project budgets lead to increased demands for graduate research assistants and postdoctoral fellows. Each faculty member wants to maximize his or her own research output and this puts pressure on graduate schools to expand enrollments. Concern about future employment prospects for one's students often falls by the wayside. Inasmuch as the prestige of an academic department is based upon the research accomplishments of its faculty members, department behavior often mimics the behavior of its individual faculty members.

From the perspective of U.S employers of PhD level scientists and engineers, their goal is to attract and retain talented PhDs at the lowest possible costs. Hence immigration policies that enhance the ability of foreign students to study in the U.S and foreign PhDs, whether they receive their training in the U.S. or abroad to work here will be favored by them.

From the perspective of an academic institution, budget situations dictate the extent to which the institution has the resources to bid for top faculty prospects or is forced to settle for lesser quality faculty whose salaries it can afford. Most American college students are educated at public institutions and hence most American faculty members are employed at public institutions. Over the last quarter of a century, state government budget problems, coupled with the increased demand on their budgets for expenditures in areas other than higher education (health, criminal justice, elementary and secondary education), have led state appropriations per student in public higher education to decline relative to tuition levels at private academic institutions. Even with roughly equal percentage increases in tuition at public and private higher education institutions during

the period, because public tuitions started at much lower levels, expenditure per student levels in public higher education have progressively fallen behind expenditure per student levels in private higher education.

The result, which I have discussed in detail elsewhere, has been a substantial decline in full-time faculty salaries at public higher education institutions relative to full-time faculty salaries in private higher education institutions and the growing tendency, to which I have already alluded here, to substitute part-time and full-time non tenure track faculty for full-time tenure track faculty.[15] Not surprisingly voluntary faculty turnover is also higher at public higher education institutions than at private higher education institutions, but this turnover does not lead to the creation of an equal number of new full-time tenure track faculty positions.[16]

Perhaps paradoxically, at the same time that fewer new full-time tenure track faculty positions are being created, the competition to attract the very top young scientists and engineers has heated up. A recent survey conducted by the Cornell Higher Education Research Institute found that start up cost packages for new assistant professors at our nation's private research universities were typically in the $400,000 to $500,000 range, with packages at the publics somewhat lower.[17] Packages needed to attract senior faculty are considerably larger and often exceed $1,000,000. Because private universities more often have access to endowment income and annual giving streams from which they can obtain funds for start-up cost packages, it is not surprising that public universities, more often than private universities, reported to us that they obtained at least part of the funding needed for start-up cost packages by keeping faculty positions for scientists and

[15] Ehrenberg (2003)
[16] Nagowski (forthcoming)
[17] Ehrenberg, Rizzo and Condie (2003)

engineers vacant until salary savings could be accumulated to cover these costs. To the extent that public universities face a continual need to attract new faculty, this suggests that there will be a permanent level of vacancies at these universities and thus a further de facto reduction in the size of the full-time faculty at them.

IV. The Social Interest

A declining availability of full-time tenure track faculty positions in American higher education institutions surely will reduce the attractiveness to American college graduates of PhD study in the sciences and engineering. Is the trend of substituting part-time and full-time non tenure track faculty positions for full-time tenure track positions, especially at public institutions, likely to continue in the future? To the extent that governors and state legislatures are concerned more about the undergraduate degrees that are generated by their public higher education institutions and less about these institution's graduate degree production, I fear that the answer will be yes, unless researchers can demonstrate that the shifts in faculty composition are having adverse effects on undergraduate students. After all, from the perspective of an economist, substituting cheaper for more-expensive inputs to minimize the costs of achieving a given level of output is very rational. In recent research, Liang Zhang and I have shown that the increasing use of contingent faculty is associated with higher drop-out rates and lower graduation rates, other factors held constant, but more studies of this type need to be undertaken to make this case.[18]

Cutbacks by states in their funding for public higher education institutions may seem irrational, given the research I cited above that ties economic growth to science and engineering research, both at the national and local levels. Many states seems aware of

[18] Ehrenberg and Zhang (forthcoming)

the importance of scientific and engineering research to their states and are engaged in major efforts to boost research infrastructure in their states. However, boosting research infrastructure is not the same as providing funding for educating undergraduate and graduate students in science and engineering. So why the disconnect? Why are states starving their public higher education systems at the same time they are funding research infrastructure.

Perhaps the answer is that the mobility of highly educated workers severely limits the returns that state governments receive from investing in public higher education. Research suggests that the proportion of the adult population in a state that is college educated is only very loosely tied to the expenditures that state governments are currently making on their public higher education systems.[19] Paula Stephan and her colleagues have also shown that some states are big net importers from other states of new PhDs in science and engineering working in industry (for example, California and Massachusetts), while other states are big net exporters (for example, many of the Midwestern states).[20] While the latter states benefit from the research that their PhD students help to produce during their graduate careers, these states will not reap as much of the benefits of the new PhDs' research when they move to out-of-state employment.

Hence the policy dilemma: Evidence suggests that our nation's level of economic growth depends upon the investments we make in research and development and these in turn depend upon a steady flow of new science and engineering PhDs. However, state budget problems, coupled with the mobility of new science and engineering PhDs, do not provide states with the incentive to make socially optimal levels of investment in

[19] Bound et. al. (2004)
[20] Sumell, Stephan and Adams(2003)

graduate education in science and engineering at their public higher education institutions. This suggests that ultimately it must be the federal government that plays the role of guaranteeing that our nation generates an adequate supply of graduate scientists and engineers.

How this is translated into changes in federal policy is an open question. However, as one of the many PhDs who was attracted to PhD study by the availability of multiyear National Defense Education Act Fellowships in the mid 1960s, enhancing funding for PhD fellowships and traineeships surely is one option. So too is providing incentives to institutions to increase the fraction of their graduates who receive undergraduate degrees in science and engineering and policies that encourage innovation in graduate training programs in the sciences and engineering that explicitly will explicitly prepare PhD students for careers outside academia.[21]

[21] Romer (2000)

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