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Opening (and Closing) Doors: Country-Specific Shocks in U.S. Doctorate Education

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Country-Specific Shocks in U.S. Doctorate Education

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DISCLAIMER: The use of NSF data does not imply NSF endorsement of the research methods or conclusions contained in this report.

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INTRODUCTION

The representation of students from abroad among doctorate recipients – particularly in science and engineering – in U.S. universities has increased dramatically in recent decades, rising from 27 percent in 1973 to over 50 percent in the 2005 year of observation. This growth has not been uniform across source countries, and increases in doctorate attainment have been particularly large among those countries where the rate of growth in undergraduate degree attainment has exceeded that in the United States (Bound, Turner, and Walsh forthcoming).

Although some of the changes in doctorate attainment by country of origin reflect relatively smooth adjustments in the choices of students from nations with long-standing diplomatic and trade ties with the United States, other adjustments reflect sharp changes in access to the U.S. education market. Perhaps the most dramatic examples of the latter type are the entry into the United States of PhD students from China in the early 1980s and from Eastern Europe and the former Soviet Union in the late 1980s and early 1990s.

Such sharp changes present both challenges and opportunity for economic analysis. In this paper, we are interested in modeling the flow of students from abroad into U.S. doctoral programs. As a starting point, we show how changes in access to the U.S. education market correspond to changes in the granting of U.S. doctorates to students from particular countries. More generally, we suggest the potential for an important dynamic whereby the initial flow of students into the United States from countries with sufficiently strong growth trajectories eventually expands the capacity of the local higher education institutions and skill-intensive industries. To the extent that doctoral recipients return to their home countries, then, “brain drain” and attendant negative net flows are not inevitable consequences from the flow of students into the United States at the graduate level.

We begin with a review of the overall rise in the participation of foreign students in U.S. doctoral programs and then focus on specific political transformations and the associated opening of doors to graduate education in the United States to additional foreign students. We then sketch a model of transition in the pattern of PhD attainment before turning to empirical analysis of entry to U.S. programs among doctoral students by country of origin after political transitions open access to U.S. universities.

Focusing on China, Eastern European countries, and the former Soviet states, we note a clear pattern: opening markets to trade and reducing travel restrictions coincide with an immediate and sharp increase in the entry of foreign graduate students, leading to U.S. doctorates for students from other nations. Our analysis suggests that access to U.S. universities and their doctoral programs may be important for those nations with transitioning economies, which may have long-term demand for highly skilled labor but little short-term capacity within their own universities to produce these skills. Although changes have been more gradual in other countries with strong development trajectories, such as India and South Korea, there is good reason to
suggest that access to higher education in the United States also has served to build the pool of highly trained labor and to facilitate the expansion of higher education in the home country.

FOREIGN PARTICIPATION OVER TIME IN U.S. DOCTORAL EDUCATION

As early as the first part of the twentieth century, universities in the United States attracted a substantial number of students from abroad, particularly in the sciences. For example, in the period from 1936 to 1956, nearly 20 percent of PhDs in engineering and about 12 percent of PhDs in the life sciences were awarded to students who had completed undergraduate studies in their countries of origin. Advances in air travel and global communication combined with the strengthening of U.S. universities in the 1950s and 1960s (stimulated by the growth of federal research investments) made advanced study in the United States increasingly attractive to foreign students thereafter.

The Survey of Earned Doctorates provides a comprehensive picture of PhD recipients from U.S. universities by country of origin from the late 1950s to the present; Figure 1 shows the overall trend in PhDs awarded by U.S. universities and the respective series for U.S. and non-U.S. degree recipients.¹

The overall rise in PhDs awarded to students from abroad from the late 1950s to the mid-1990s is clear, with a considerable acceleration in growth beginning in the late 1970s. This pattern is accentuated in the sciences (see Figure 2). In economics and engineering, degrees awarded to students from abroad have outnumbered those awarded to U.S. students for a number of years; in all but the life sciences, the foreign-born share has equaled or exceeded the share of U.S.-born PhD recipients.

Focusing on explaining the rise in the participation of students from abroad in U.S. doctoral programs, Bound, Turner, and Walsh (forthcoming) emphasize that much of the rise in foreign doctorate attainment can be explained by the growth in demand for U.S. degrees from abroad, with countries such as India and South Korea expanding undergraduate degree attainment at a rate greater than that observed in the United States. In addition, political shocks in countries such as China have opened a new source of “realizable demand” for U.S. graduate education that had been largely closed in the 1960s and 1970s. A final explanation offered by Bound, Turner, and Walsh (forthcoming) is that substantial increases in public support for science and engineering research (and, in turn, for graduate education) may yield somewhat greater expansion in the demand for doctoral education among foreign students.²

¹ The Survey of Earned Doctorates is an individual-level census of recipients of doctorates at U.S. institutions. Because survey participation is often coupled with the formal process of degree receipt, response rates have been quite high.

² The argument is that the elasticity of demand among foreign students may be somewhat larger than among U.S. students if foreign students are simply choosing where to attend graduate school rather than weighing the choice between a graduate program and an alternative profession.
Figure 1. PhD Degrees Awarded by US Universities and National Origin, 1958-2003

Source: NSF, Survey of Earned Doctorates microdata and, before 1958, National Academy of Sciences (1958). National origin is defined by the country in which an individual went to high school.
Figure 2. PhD Degrees Awarded by U.S. Universities & National Origin, 1958-2003

Panel A. Physical Sciences

Panel B. Life Sciences

Panel C. Economics

Panel D. Engineering

Source: NSF, Survey of Earned Doctorates microdata. National origin is defined by the country in which an individual went to high school. Fields defined using NSF classification, from SED annual reports.
A point of emphasis of the Bound, Turner, and Walsh (forthcoming) analysis is that there has been considerable heterogeneity across source countries, both in the overall representation of PhD students in the United States over time and in the quality of programs attended by foreign students. The returns of a U.S. PhD relative to the best alternative in the home country determines the decision to pursue graduate education in the United States; thus, selection varies markedly across countries. The result is differences in the rate at which foreign students pursue U.S. PhDs and the extent to which these students are concentrated in the most highly ranked PhD programs. Necessarily, weaker options in the home country pull more students toward study in the United States, while stronger home country universities produce lower aggregate levels of foreign study in the United States, though often higher levels of skills among those students who do choose to study in the United States. The focus of this analysis is on what happens as other nations open (and close) opportunities for doctoral study in the United States. A particular advantage of the Survey of Earned Doctorates for this analysis is that it permits us to organize recipients of doctorates from U.S. universities by country of origin (distinguishing place of birth, place of high school, and bachelor’s degree institution) and year of entry into graduate school. The year of entry into graduate school, as distinguished from the year of receipt of the PhD, is particularly helpful because time to degree varies appreciably, and it is thus difficult to discern sharp changes in access to U.S. higher education from year of receipt alone. We will discuss relevant economic theory before illustrating the link between political shifts and doctorate attainment in the data.

EXPECTED RESPONSES WITH THE OPENING THE U.S. MARKET

Beyond exchanges in goods and services, one of the most visible demonstrations of the opening of trade relations with the United States is the development of education exchanges. Some educational exchange is largely symbolic, wrapped in the rhetoric of improving cross-cultural understanding. Yet the visible flows of foreign students to U.S. institutions following political and economic transformations are grounded in basic economics of skill acquisition and comparative advantage. As with the more general pattern of foreign study in the United States, it is the strong advantage of graduate education that leads to the immediate draw of students to universities in the United States. Because few students from nations with economies in transition can negotiate the hurdles to enter education programs that require full payment of tuition (undergraduate and professional programs), students from these countries studying in the

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3 Although it is difficult to rank universities in an international context, the top U.S. universities are often considered leaders at an international level. One effort has been made to compare universities on an index scale including measures such as Nobel Prize laureates, articles published in major scientific publications, and citations finds that fifteen of the top twenty, as well as thirty-five of the top fifty, universities are in the United States (Shanghai Jiao Tong University Institute of Higher Education 2003). While the strength of U.S. universities at the top of the international rankings is widely recognized, it should also be noted that there is considerable variance in the quality of U.S. doctoral programs. One British observer, comparing the United States and the United Kingdom, has noted that “the U.S., with 4,000 institutions of higher education, probably has 50 of the best universities in the world and undoubtedly has 500 of the worst” (Stevens 2004, cited in Bowen, Kurzweil, and Tobin 2005, p. 314).
United States are found disproportionately in doctoral programs, as these programs are likely to offer financial support through fellowships, research assistantships and teaching assistantships. Moreover, pursuing a PhD in the United States offers not only the direct advantage of skill acquisition but also the indirect benefit of greater access to the U.S. labor market.

Of theoretical and empirical importance in modeling the educational flows in transition economies is the extent to which transition countries hold (or actively seek through government initiatives) a long-term comparative advantage in the production of goods and services intensive in the type of highly skilled labor represented by PhD recipients. If this is the case, there is good reason to believe that the flow of students from abroad to receive doctorates in this country is an intermediate input in the production of these skill-intensive export goods. To the extent that the infrastructure of the home country improves over time, and as PhD recipients educated in the United States return to their home countries, we would expect that the steady-state demand for U.S. doctorates will decline in the (very) long run. In this scenario, foreign students’ attainment of U.S. PhDs can be viewed quite legitimately as an important component of future development and growth for both the private and public sectors in countries of origin.

If, on the other hand, the economy in the home country has few economic opportunities for highly skilled workers, or if educational institutions there do not improve, we would anticipate the continuation of the flow of foreign students into U.S. PhD programs. Moreover, for those (primarily “least-developed”) countries in which there is little or no production of skilled-labor intensive goods, the flow of students into U.S. PhD programs will likely be permanent, fulfilling developing country fears of “brain drain.”

Our hypothesis about the flow of students subsequent to political shocks is captured by the simple time path sketched in Figure 3. Before the opening of educational exchange there is little (if any) doctorate attainment in the United States among students from the host country. The establishment of full trade and diplomatic relations yields a sharp increase in study in the United States. Yet, unlike trade in final products, which may continue indefinitely on an upward trajectory, doctorate attainment eventually declines from this peak. One mechanism behind the

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4 For the transitioning countries at the center of this study, there is considerable variation in the initial quality and functioning of the university systems in the home country. China bounds one end of the distribution with a university system largely in disarray in the late 1970s following the Cultural Revolution; indeed, the lack of options in the home country was a primary motivation for sending students to the United States and Canada. To varying degrees, Eastern European Communist rule did not dismantle university infrastructures with long historical roots, though social science subjects such as economics were not offered at levels that met international standards. For the Soviet Union, the end of the Cold War did not bode well for the university system, which had been quite strong in the sciences, as state support was largely eliminated.

5 In the very long run, as other countries’ educational infrastructure improves, we might expect systematic sorting among PhD students across the globe; indeed, one might argue that strong institutions in the United States captured foreign demand that a century earlier necessarily would have belonged to Oxford and Cambridge Universities in England, or the Sorbonne in France. There is no reason not to expect competition for top students from now-emerging educational powerhouses in future decades.

6 To this end, models of “brain drain” – where leaving the country to study abroad often ends up being a permanent emigration – apply most directly to very poor countries.
A sharp peak is the presence of pent-up demand; had the market not been closed, one would have expected at least some previous flow into U.S. doctoral programs. Although many of those denied opportunities to pursue U.S. PhDs will have made other investments or will be of an age at which insufficient years are left to accrue the benefits of a PhD, some marginal older students still will be likely to have a positive demand for U.S. doctoral study opportunities. If this is the case, the age distribution of students entering U.S. doctoral programs in the years immediately following a diplomatic shock may be somewhat wider, including more older students, than those entering in later years – a hypothesis that may be checked easily within our data set.

**Figure 3.** Dynamic Effect of Policy Shock on U.S. PhD Attainment for Transition Country

After the initial peak has subsided, the longer-term trajectory of PhD attainment may increase or decrease in response to shifting economic and institutional conditions. If, holding higher education resources and infrastructure fixed, the economy in the home country expands in relatively skill-intensive sectors that demand engineering and science PhDs, the demand for U.S. degrees may reasonably be expected to continue to rise. If, on the other hand, the educational infrastructure in the home country improves with the rest of the economy, then “residual” demand for U.S. PhD degrees may level off or even decrease as the institutions in the home country become better substitutes for U.S. universities. The time path of U.S. degree attainment in this scenario would depend, predictably, on the relative rate of growth of the local high-tech sectors (demand for PhD holders) and local institutions (supply). Further, as local education institutions improve, we would expect to observe a greater concentration of students at the best U.S. institutions; we are also able to examine this proposition in our data.
Although we focus primarily on the opening of markets in this chapter, it is natural to discuss the closing of markets brought about by regime shifts that close off trade and diplomatic exchange with the United States. Such shifts include the Hungarian Revolution of 1956 or the Iranian Revolution of 1979. The outcome of market closure leading to sustained decline in the flow of students into U.S. doctoral programs is, perhaps, tautological. What we predict (and observe) is somewhat more complex, with a short-term period resembling refugee emigration, as some very able potential students outside the current regime escape through U.S. graduate education, producing a short-term spike in doctorate attainment.

OPENING MARKETS AND FOREIGN DOCTORATE ATTAINMENT

The data show clearly that opening markets – both politically and economically – generally leads to a substantial and rapid flow of students into U.S. PhD programs. Perhaps not surprisingly, those students coming to U.S. institutions after political transitions disproportionately study in the sciences.\(^7\) We present here the data on PhD recipients by country of origin organized by year of graduate school entry.\(^8\) Because year of PhD receipt reflects variation in time to degree as well as year of program entry, the changes tied to market transitions are much more visible when we organize the data by year of entry into graduate school.

One downside of organizing the data by year of entry to graduate school is that the most recent cohorts have somewhat fewer years to complete graduate study within the time frame of our data availability, as such total degree attainment for these cohorts is truncated. Moreover, as will be shown in the empirical work that follows, the data on year of entry appears to represent year of entry to master’s degree programs in cases (such as China’s) where it is common for students to finish a master’s degree in their home country before studying in the United States. Assuming that students go directly from master’s degree to PhD programs, we make some adjustment to project the year of entry to U.S. doctoral programs as the year of master’s completion for those students with foreign master’s degrees. We will proceed now with an overview of the specific of cases of China, Eastern European countries, and the former Soviet states, and then turn to a discussion of the general findings from these cases.

CHINA

There has been a decisive increase in the number of U.S. degrees, largely in the sciences, awarded to students from China over the last 25 years (see Figure 4). These numbers rise from “tens” in the 1970s to thousands of degrees awarded in the 1990s. Corresponding to the growth

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\(^7\) It is likely that a primary explanation for these trends is that they are a reflection of the undergraduate training received in the home countries, reflecting the emphasis of the Chinese institutions on developing engineering strengths in the late 1970s and the emphasis on math and physical sciences under the Soviet Cold War regime. Moreover, we expect that this pattern of concentration is consistent with subject matter that would bring a relatively high return in the home countries.

\(^8\) Rather than using country of birth, which may include some students coming to the United States at young ages, we organize the data by country of high school attendance.
**Figure 4.** PhD Degrees Awarded by U.S. Universities to Students from China

Panel A. Doctorates awarded to students from China by year of PhD

![Graph showing PhD degrees awarded to students from China by year of PhD](image)

Panel B. Doctorates awarded to students from China by year of graduate school entry

![Graph showing PhD degrees awarded to students from China by year of graduate school entry](image)
in degrees awarded in the 1990s in the top panel, the bottom panel shows degrees attained as arranged by year of graduate school entry, along with an adjustment for students receiving master’s degrees in China before coming to the United States, which is particularly common in the initial cohorts.

To understand the dynamic in the evolution of student flows from China, it is important to consider the link between political and educational transitions. University activity during Mao Zedong’s Cultural Revolution (1966-1976) was largely disrupted, and many facets of universities ceased operations. Immediately thereafter, China sought to jump start its development process through access to science and engineering technology via U.S. universities. The establishment of diplomatic relations with the United States in 1979 led to the (re)opening of educational exchange between the two countries. A disproportionate share of the first wave of exchange students coming to the United States were related to high-level Chinese officials, including the son of former Chinese Communist Part head Deng Xiaoping and the son of foreign minister Huang Hua (Wong 1981), though there was also considerable competition among U.S. universities to identify the most talented among the Chinese students.

The several age cohorts that went to college in 1976, immediately after the end of the Cultural Revolution, had a dramatic impact on doctoral degree attainment. Yet, with very few college graduates available in the 1970s, the surge in Chinese participation in U.S. graduate education was delayed until the mid-1980s; students had first to acquire the necessary undergraduate credentials before they could apply for graduate education. Most notable is the group of students receiving bachelor’s degrees in China in 1982, with many students from this cohort entering graduate school that same year. Many in this cohort appear to have finished master’s degrees in China before entering U.S. PhD programs in about 1984 (compare “S&E” and “S&E, MA adj” in Figure 4). Note that after this initial large influx of doctoral students,

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9 For example, in 1981, the United States granted 2,678 F-1 (student) visas and 3,121 J (exchange) visas to students from China. By 1991, the corresponding numbers were 14,594 F-1 and 7,431 J visas. A concern that began to play out in the 1990s was that some Chinese students saw student visas from U.S. institutions in fields such as physics and mathematics as points of entry to either the U.S. labor market and lucrative fields such as electrical engineering. An article in Physics Today (Hargreaves 2001) discusses concerns about the unusually high dropout rate among students from China.

10 To illustrate this concentration, of the 32,127 students from China receiving U.S. PhDs between 1985 and 2003, 25 percent received bachelor’s degrees in 1982, and 40.3 percent entered graduate school between 1982 and 1985, with 12 percent entering in 1982 alone.

11 The establishment of networks early on was particularly important in opening doctoral education. One important example was the China-United States Physics Examination and Application (CUSPEA) program initiated in the fall of 1979 by the Chinese American Nobel Laureate physicist T. D. Lee of Columbia University. The intent of the initiative was to identify gifted graduate students through examination in China and to place these students at U.S. universities. During the course of the program, CUSPEA placed more than nine hundred students in physics programs at U.S. universities. To put these numbers in perspective, the total number of PhD degree recipients from China receiving degrees in physics between 1980 and 1992 was 1,062. Of course, there were other channels through which Chinese students could study physics in the United States, but the CUSPEA program clearly had a substantial impact in generating a network or link between leading U.S. and Chinese universities.
we see some retrenchment with current levels of PhDs awarded well below the initial post-transition peak. From the early 1980s to the early 1990s, U.S. universities awarded more PhDs to students from China than did Chinese universities. In the last decade, doctoral-level instruction in China has continued its exponential growth, and degrees awarded to Chinese students by Chinese universities now exceed the number awarded by U.S. institutions.

**EASTERN EUROPEAN COUNTRIES AND THE FORMER SOVIET STATES**

For Eastern Europe, access to Western markets in general, and U.S. education in particular, came to different countries at different points in time. Some cases of political change, such as Romania’s, were unambiguously revolutionary, while other countries, most notably Hungary and Poland, experienced more gradual political transitions. This differential rate of opening across Eastern European countries is clearly in stark contrast with China’s experience. A further fundamental difference between the Eastern European countries and China is that higher education institutions continued to operate under Communist Party rule and a number of Eastern European countries had relatively uninterrupted collegiate traditions going back several centuries.

Figure 5 presents the pattern of award of PhDs to students from Eastern European countries and the former Soviet states by year of graduate school entry. Bulgaria, Czechoslovakia (we combine both the Czech Republic and Slovakia in later years), Romania, and the former Soviet states demonstrate sharp increases in entry into U.S. programs among doctorate recipients. In the Czech Republic, student protests led to the Velvet Revolution and the end of Communist rule in November of 1989. The transition from Communist rule was somewhat more violent in Romania with the overthrow of the Communist regime of Nicolae Ceauşescu in December 1989.

For Poland and Hungary, the transition is much more gradual, appearing to start in the early 1980s. At the frontier, labor turmoil and the Solidarność (Solidarity) movement in Poland during the early 1980s were quite visible to the West, generating considerable support from the United States throughout the decade; the end of Communist Party rule in 1989 could be viewed, therefore, as perhaps more evolutionary than revolutionary. One manifestation of this gradual opening of exchange with Poland is the incremental increase in Polish students pursuing PhDs at U.S. universities that began in the mid-1980s.

After the fall of the Berlin Wall in 1989, notable initiatives among the governments of Eastern Europe included efforts to reconstruct systems of higher education, moving away from the compartmentalized and specialized organizations adopted under Soviet influence. Moreover, other Western countries and U.S. philanthropic interests were eager to promote the development of university infrastructure (libraries and computing facilities) as well as advanced graduate capacity. To illustrate, Quandt notes, “One of the first projects [as an adviser to the Andrew W.
Mellon Foundation] was the establishment of the Center for Economic Research and Graduate Education, a joint effort by Charles University (Prague) and the University of Pittsburgh to create a Western-style PhD program in economics” (1992). Similarly, other major U.S. institutions such as the Ford and Soros Foundations have been active in attempting to strengthen higher education in Eastern Europe.

While a quite different type of change than the opening of access to U.S. universities that has occurred in the early 1990s, the most visible episode in the graph for Hungary is the spike in students entering U.S. graduate programs in 1957, subsequent to the revolution. With the Soviet occupation and ensuing violence after student protests in October 1956, many students and citizens fled to the West. In the United States, nonprofit organizations and universities made considerable efforts to aid refugee students from Hungary, with one estimate suggesting that about 1,000 students received financial assistance to continue education (Ficklen 2006). This is a salient example of what in other contexts economists have described as “refugee sorting” (Borjas 1987), with the clear implication of a loss of talent for the home country as many of the best students left the country.

On the surface, the dissolution of the Soviet Union and the opening of U.S. education to these formerly Soviet students would appear very similar to the case of the Eastern European countries. In the years before 1989, barely a trickle of students from the Soviet Union completed doctoral degrees in the United States, with most of those students likely related to political émigrés. Then, during the Soviet presidency of Mikhail Gorbachev, perestroika initiated the modest exchange of graduate students and scholars (Raymond 1989) and much more significant numbers of graduate students came to the U.S. with the collapse of the Soviet Union in 1991. But the collapse of the former Soviet Union also led to significant declines among the traditional Soviet universities, which had long-standing strengths in the physical sciences and had been generously supported by the government during the Cold War.12 By one estimate, funding for science in Russia declined 44.2 percent between 1989 and 1991 (Shkolnikov 1995). With the formal dissolution of the Soviet Union in 1991, students entered graduate programs in the United States in substantial numbers, with further increases through 1993. As former Soviet universities have continued to lose funding rather than increase in strength – as is the case in a number of the Eastern European countries – there is less motivation for U.S.-educated students to return to their home countries as there were few prospects for employment and high-level scientific research funding.

12 With the dissolution of the Soviet Union in 1991, the now separately identified former Soviet republics are Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
Figure 5. U.S. PhDs Awarded to Students from Eastern European Countries and Former Soviet States

Bulgaria

Czech Republic
Hungary

Poland
GENERALIZATIONS FROM MULTIPLE MARKET OPENINGS

From this set of countries experiencing the opening of access to U.S. higher education as well as trade more generally, there are some common themes. Beyond the increases in PhD pursuit in the initial years following opening of study in the United States, there is not a continued increase in PhD receipt for students from these countries. Quite the contrary, doctorate receipt tends to decline among later cohorts of graduate school entrants. The case of China is, perhaps, the most dramatic in this regard. The cohort that entered college in 1978 and, in turn, started graduate study between 1981 and 1985, is extraordinary in representation among U.S. PhD recipients in the sciences. To illustrate the unusual impact of this single cohort, we note that of the PhD degrees awarded to students from China in the decade between 1985 and 1994, 46.6 percent of the 11,197 awardees had started college in 1978. The same pattern appears to some degree in the East European countries and former Soviet states.13

In considering the mechanism generating the transition, we have suggested that one element in this dynamic is that opening the option of doctoral study in the United States comes with high initial flows from pent-up demand. As such, we might expect PhD recipients from these initial cohorts to be somewhat older than those pursuing U.S. doctoral study in the subsequent years. Figure 6 starts with age distribution at the time of entry into graduate study among PhD recipients in the case of China, in comparison with U.S. doctorates and doctorates from nontransitioning countries, in three-year intervals.

While there is little change over the 12-year interval in the control groups, doctorate recipients from China are increasingly “younger” with ages at graduate school entry more tightly clustered near the ages 22-23. In turn, the mean age at entry among Chinese doctorate recipients fell from about 24.2 years in the early 1980s to 23.7 years for those entering graduate programs between 1992 and 1994. Turning to the Eastern European countries, we see a similar pattern in all but Poland and Romania in Figure 7. While the exhaustion of the pent-up demand is potentially one of the factors that explains the stabilization in the rate of doctorate attainment among transitioning countries, it is also possible that growth in home country university sectors reduce the flow of students into the United States in subsequent cohorts.

A second suggested demonstration of the connection between U.S. doctorate attainment and economic transition is the potential for changing selection into doctorate-granting institutions in the United States. In the case of China, where we have observed PhD attainment for about two decades since the start of that country’s transition, there have been substantial changes in the concentration of students by program quality (see Table 1). 

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13 One might argue that the same pattern is hard to identify in the data for Eastern European countries and former Soviet states because students in the most recent graduate cohorts entering from these countries may still be in graduate school with continuing likelihood of receiving PhDs. To address this concern, we also plot the pattern of degree receipt within eight years of graduate school entry, with common truncation across cohorts. Clearly the patterns persist.
Figure 6. PhDs awarded by age, year of graduate entry, and country [US, Other, and China]

U.S.

Other Non-Transition Countries

China
Figure 7. PhDs awarded by age, year of graduate entry, and country [Eastern Europe and Former Soviet]

Bulgaria

Czech Republic

Hungary
Poland

Romania

Former Soviet States
Table 1. Share of degrees awarded to students in top-15 doctorate programs by field and country of origin

<table>
<thead>
<tr>
<th>Country of Origin</th>
<th>Year of Graduation</th>
<th>Physics</th>
<th>Chemistry</th>
<th>Bio-Chemistry</th>
<th>Economics</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1980-84</td>
<td>0.151</td>
<td>0.131</td>
<td>0.093</td>
<td>0.201</td>
<td>0.202</td>
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<td></td>
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<td>0.189</td>
<td>0.131</td>
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<td>0.300</td>
</tr>
<tr>
<td>India</td>
<td>1980-84</td>
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<td>1995-99</td>
<td>0.338</td>
<td>0.215</td>
<td>0.257</td>
<td>0.317</td>
<td>0.471</td>
</tr>
<tr>
<td>Taiwan</td>
<td>1980-84</td>
<td>0.204</td>
<td>0.153</td>
<td>0.133</td>
<td>0.166</td>
<td>0.307</td>
</tr>
<tr>
<td></td>
<td>1985-89</td>
<td>0.183</td>
<td>0.155</td>
<td>0.157</td>
<td>0.298</td>
<td>0.332</td>
</tr>
<tr>
<td></td>
<td>1990-94</td>
<td>0.240</td>
<td>0.237</td>
<td>0.188</td>
<td>0.217</td>
<td>0.443</td>
</tr>
<tr>
<td></td>
<td>1995-99</td>
<td>0.360</td>
<td>0.250</td>
<td>0.320</td>
<td>0.235</td>
<td>0.470</td>
</tr>
<tr>
<td>USSR</td>
<td>1990-94</td>
<td>0.218</td>
<td>0.184</td>
<td>0.133</td>
<td>0.226</td>
<td>0.338</td>
</tr>
<tr>
<td></td>
<td>1995-99</td>
<td>0.319</td>
<td>0.163</td>
<td>0.077</td>
<td>0.358</td>
<td>0.387</td>
</tr>
</tbody>
</table>

Source: Authors’ tabulations from the Survey of Earned Doctorates (restricted access file).

Particularly in the early 1980s, it is clear that students from China were concentrated in relatively low-ranked programs, with more than 50 percent of degree recipients starting their degrees between 1981 and 1984 in chemistry, physics, and life sciences receiving doctorates from institutions outside the top fifty programs. Yet, over the course of a decade it appears that the representation has shifted toward higher-ranking programs and recent entry cohorts are appreciably more likely to receive degrees from the top fifteen programs than those entering in the early 1980s, presumably as educational options improve in China.

Thus, a clear point from this descriptive presentation is that political transitions that open education markets, such as those that occurred in China in the early 1980s and Eastern Europe in the early 1990s, have substantial effects on participation in U.S. doctoral education. To the extent that these countries have been on steep growth trajectories, what we expect is that the initial rise
in PhD pursuit in the United States will plateau or decline, accompanied by greater selectivity among those choosing U.S. universities for study as educational options in their home countries increase. While this dynamic is most clearly demonstrated in the cases of countries with sharp policy changes, the basic intuition can be extend to countries like India and South Korea and the Chinese island of Taiwan (formerly an independent republic). In these places, economic policies that began in the mid-1970s and generated substantial expansion of trade were also accompanied by a growth in PhD attainment at U.S. institutions (see Figure 8). What we see in this figure is that there was a period of quite rapid expansion in the number of students starting (and completing) PhD programs in the United States, followed by a substantial decline that began in the late 1980s. We also find that recipients of U.S. PhDs from these countries are much more concentrated today in the top U.S. graduate programs than they were in the late 1970s, as Table 1 shows clear increases in the share receiving degrees from the top fifteen U.S. programs.

Yet, as fewer students from these countries are pursuing PhDs in the United States, Table 2 makes clear that the higher education sectors – and advanced degrees in the sciences, specifically – have grown at an extraordinary pace during the last 15 years. To illustrate, the number of science and engineering PhD holders produced in Taiwan increased from 109 in 1985 to 1,167 in 2003, while in South Korea the number grew from 281 in 1983 to 3,225 in 2002. Such evidence is suggestive of a process of transition whereby substantial doctorate attainment from U.S. universities among students from these countries was part of the development of robust universities producing advanced degrees in the home country, as well as more general expansion into industries dependent on scientific research and engineering skills.

The story we have sketched, in which bright students from developing countries go abroad (perhaps even encouraged by their home governments) and eventually return to fuel economic growth is not inevitable, but depends on the persistence of positive prospects and the development of higher education institutions in the countries of origin. We suspect that the continued deterioration of universities in the former Soviet states has generated a circumstance in which few of the U.S.-educated PhD holders will return, thus more closely resembling traditional presentations of “brain drain.”
Figure 8: PhDs awarded by year of graduate school entry, India, South Korea, and Taiwan

India

South Korea

Taiwan
Country-Specific Shocks in U.S. Doctorate Education

Table 2. PhDs in Science and Engineering Fields in Asian Growth Countries

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>India</th>
<th>South Korea</th>
<th>Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>NA</td>
<td>3,886</td>
<td>281</td>
<td>58</td>
</tr>
<tr>
<td>1985</td>
<td>125</td>
<td>4,007</td>
<td>548</td>
<td>109</td>
</tr>
<tr>
<td>1987</td>
<td>218</td>
<td>4,123</td>
<td>759</td>
<td>197</td>
</tr>
<tr>
<td>1989</td>
<td>1,024</td>
<td>4,209</td>
<td>984</td>
<td>257</td>
</tr>
<tr>
<td>1991</td>
<td>1,198</td>
<td>4,294</td>
<td>1,135</td>
<td>370</td>
</tr>
<tr>
<td>1993</td>
<td>1,895</td>
<td>4,320</td>
<td>1,421</td>
<td>513</td>
</tr>
<tr>
<td>1995</td>
<td>3,417</td>
<td>4,000</td>
<td>1,920</td>
<td>650</td>
</tr>
<tr>
<td>1997</td>
<td>5,328</td>
<td>4,764</td>
<td>2,189</td>
<td>839</td>
</tr>
<tr>
<td>1999</td>
<td>6,778</td>
<td>5,317</td>
<td>2,607</td>
<td>892</td>
</tr>
<tr>
<td>2000</td>
<td>7,304</td>
<td>5,395</td>
<td>2,865</td>
<td>931</td>
</tr>
<tr>
<td>2001</td>
<td>8,153</td>
<td>5,394</td>
<td>970</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>5,527</td>
<td>3,225</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>6,318</td>
<td>1,167</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Science and Engineering Indicators, 2006. Appendix Table 2-43.

THE NEXT STEPS

What we take away from this short analysis is that political shocks in other nations, represented by the opening of trade and educational exchange, have had demonstrable effects on the flow of students into U.S. doctoral education programs. With large increases in the flow of students from China during the 1980s and subsequent increases in the flow of students from Eastern European and the former Soviet countries in the early 1990s, there is a common theme present in the data characterized by a sharp increase in the entrance of new doctoral students followed by the establishment of a steady-state flow.

Much work remains to be done on the question of how exchange in postsecondary education affects economic outcomes in the sending and receiving countries. We suggest that the impact of educating foreign students from transitioning economies like those of China and Eastern Europe has important long and short term differences from the case for poor developing countries. For transitioning economies, doctorate attainment from U.S. institutions may well prove to be an “intermediate product” used in the development of education and industry in the home country. To this end, transitioning economies may generate return migration among U.S. PhD recipients if they have strong institutions and investment in universities. As such, “brain drain” is far from an inevitable consequence of the advanced training of students from transitioning countries at U.S. universities.
REFERENCES


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