Switching Field of Study: Different Educational Pathways of Highly Educated Natives and Immigrants

THESIS

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Abstract

This paper advances understanding of immigrants’ post-immigration educational attainment by considering one aspect of horizontal stratification: switching field of study between college and graduate school and its impact on educational returns. Foreign educated immigrants with a STEM degree may be more likely to retain in STEM fields than to switch to non-STEM fields when entering a U.S. graduate school than their native counterparts. This is due to higher transferability of STEM knowledge and immigrants’ weaker context-specific knowledge. To test these ideas, I compare foreign college-educated immigrants and U.S. college-educated immigrants to U.S. college-educated natives. Data from National Survey of College Graduates show that immigrants are more likely to retain in STEM or to switch to STEM from non-STEM fields; natives are more likely to switch from STEM to law, medicine and business. These results suggest that lower educational returns among highly educated immigrants can be explained, in part, by field of study.
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Fields of Study

Major Field: Sociology
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Introduction

Are the fields of Science, Technology, Engineering and Math (hereafter STEM fields) in the U.S becoming “immigrant” fields of study? Does the immigration process alter the educational pathways of highly skilled immigrants? If so, are they more likely than native students to end up with STEM degrees? Furthermore, among students who enter advanced training beyond a college degree, do the educational pathways of foreign college-educated immigrants and U.S. college-educated immigrants differ in important ways? The traditional “science pipeline” model (Berryman 1983, England et al. 2007) studies how females leak out of the STEM fields as they proceed to higher level of education compared to males, but a parallel is yet to be drawn between natives and immigrants. Recent decades have seen natives more often leaking out of the pipeline when they proceed to higher levels compared to immigrants. According to U.S. department of education (Snyder 2001, 2010), the share of foreign students in graduate programs rose significantly in recent decades, and the increase is driven by STEM fields: in the year 1996-1997, nonresident aliens received 37.6 % of all doctorates in physical sciences\(^1\), 39.7 % in engineering, and 22.6 % in life sciences. The percentage grew to 45.9% in physical sciences, 59.4% in engineering and 28.0% in life sciences respectively

\(^1\) including mathematics, computer science, physics and astronomy, chemistry, and earth, atmospheric, and marine sciences.
in the year 2005-2006. Some scholars have asked whether the leaking of natives out of the science pipeline signals the “decline” of the sciences in the U.S. (Lowell and Salzman 2007, Xie and Killeward 2012). At the same time, the rapid growth of highly-skilled immigrants in STEM fields may also signal barriers to their social mobility, if this rapid growth is due to their lack of access to other high-status fields such as law, medicine and business.

The current study uses National Survey of College Graduate 2003 to illustrate the movement of natives and immigrants from one field of study to another in the transition from college to graduate school. If they completed their highest degree in the U.S., natives, U.S. educated immigrants and foreign educated immigrants end up in different fields of study depending on their nativity, place of college education and undergraduate major. Adopting a pathway perspective on how field of study evolves over the course of the entire tertiary education, I apply log-linear models to examine the association between the field of first bachelor’s degree and the field of highest degree. The purpose is to look at whether the U.S. educational system and labor market favor immigrants who pursue advanced degrees in STEM, but at the same time create barriers for immigrants to enter high status non-STEM fields relative to native students. The barriers are likely to be especially large for foreign educated immigrants, judging from their exceptionally rapid growth in the STEM fields. These processes are related to the growing segregation of immigrants and natives in STEM and non-STEM fields of advanced study we have seen in recent decades (Borjas 2002, 2004).

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2 Lowell and Salzman (2007) estimated that 20 percent of S&E bachelor’s degree recipients continued graduate study in non-S&E field, while Xie and Killeward believe that this is an overestimate, due to the inclusion of social sciences.

3 As in prior literature, place of education is divided into two broad categories: U.S. and non-U.S.
A Pathway Perspective of Human Capital Transferability

Past research on immigrants’ educational attainment focuses on the lower returns to foreign education compared to U.S. education at the same level, due, in part, to place of college education (Zeng and Xie 2004, Arbeit and Warren 2012). Three explanations for these lower returns are: 1) lower recognition of foreign degrees among American employers, 2) the non-transferability of certain types of knowledge across societies, and 3) the presumably lower quality of foreign education. Zeng and Xie (2004) show that educational returns are severely discounted for foreign college-educated Asian males in the American labor market, but not for U.S. college-educated Asian males, compared to native college graduates. Arbeit and Warren (2012) expand the scope of Zeng and Xie to examine these processes for female immigrants as well as for male immigrants, and for immigrants of all nativities. Their analysis shows that foreign college degrees not only affect wages, but also the type of jobs foreign educated immigrants have in the U.S. Foreign educated college graduates are less likely to find a job in their area of expertise.

Both studies, however, only examine college graduates. For those who obtain higher education after college, we need to know their educational pathways from college to the final level of education in detail. This is because two types of changes in educational pathways may impact students’ labor market outcomes. On the one hand,
place of education might vary at multiple levels of education, creating different labor market outcomes for those who changed place of study at higher level and those who did not. Tong (2010) discovered that immigrants who obtain both their undergraduate and graduate degrees in the U.S. have higher economic returns than students who have a foreign undergraduate degree and a U.S. graduate degree. While both groups attained their highest level of education in the U.S., those with a foreign bachelor’s degree more disadvantaged in terms of their income. Tong believes that this is because the U.S. college education provides a chance to acculturate to the English language and develop contextually specific skills. On the other hand, people may change their field of study in a new place of education, if the initial field of study is less advantageous in this new location. While Tong accounts for the pathways consisting of different places of education for immigrants, she does not consider pathways consisting of different fields of study and how these differences impact their educational returns. Although non-immigrants can change their field of study as they proceed to higher levels, immigrants may be more likely to do so when they discover that in the destination country, the prospect or popularity attached to a field of study is different from that in their home country. To avoid lower returns to certain types of foreign education, do foreign college-educated immigrants switch to another field at graduate level where they can transfer their skills more smoothly and avoid relying on contextual specific knowledge too much? For example, a foreign student with a bachelor’s degree in finance has little knowledge of the legal system and the actual practices of business in the U.S. To better apply his expertise, he may choose to pursue a higher degree in math rather than retaining in
business, because the math specific knowledge is most transferable part of his bachelor’s degree.

In this paper I advance the understanding of human capital attainment between immigrants and non-immigrants by examining their horizontal stratification at multiple points in the educational pathway. In addition to field of study, place of education is a dimension of horizontal stratification, and so the immigrant sample is divided into foreign educated and U.S. educated subgroups. I observe horizontal stratification over the course of a student's tertiary education, because a graduate education adds to the benefits of a college education in terms of enhanced social status, higher life time earnings, upgraded occupational status, better working conditions and lower probability of unemployment (Perna 2004). The pathway approach overcomes the deficiency of treating college education and graduate education as qualitatively homogeneous. In particular, the qualitative difference between a person's college education and graduate education can be created through an important transition: switching field of study. Switching field of study is a type of adjustment individuals may make in order to adapt to the changing characteristics of fields, educational systems, and the labor market. The decision of entering a field reflects the extent to which people can meet with the structural requirements in that field of study. The final field of study has significant impact on their future social mobility. The innovation of this paper is to depict the pattern of field switching in the transition from college to graduate school. In this way, it treats field of study as a series of changes, rather than a static part of people’s human capital that remains the same for college and graduate school.
The Universalism and High Transferability of STEM Fields

Evidence from national surveys (see Appendix A for estimates from Survey of Income and Program Participation) indicates that people in STEM occupations have lower incomes as well as lower income growth over time when compared with people in medicine, law and some fields of business. Moreover, STEM fields are typically more competitive and entail higher risks than other high status fields, because they have long periods of training and only a small proportion of would-be scientists enjoy the optimal rewards of making original discoveries/breakthroughs and gaining recognition for their contributions to science (Xie and Killeward 2012:42). The majority of scientists endure long periods of training for post-docs and difficulties in finding federal funding and suitable employment. While the obstacles to success in science are similar for both native and immigrant STEM undergraduates, their ability to change educational pathways at graduate level may differ. Yet in prior studies, it is not clear whether there are differences between natives and immigrants in the probability of switching field of study. In this

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4 NSCG 2003 has a wide distribution of years of college graduation. If assuming that in earlier decades, the advantages of professional fields relative to STEM fields are smaller than as they are now, then analyzing a sample with both students graduated in earlier decades and students graduated in more recent decades can be problematic. Nevertheless, it does not necessarily bias the analysis and results of the native-immigrant comparison. This is because the current study makes a cross-sectional comparison rather than a longitudinal one. Given a certain time period, native and immigrant college graduates should be subjected to the same labor market situation, and should respond to the opportunities or constraints in similar ways. On the other hand, the log linear analysis will be less reliable when limiting the sample to a more recent subset (e.g., students graduated 10 to 15 years prior to data collection), because the greatly reduced sample size will create small number of cases or zero case in the contingency table cells, as will be shown in the method part. In fact, descriptive results from NSCG 2003 indicate that percentage switched from STEM to professional fields does not increase steadily from the 1960s to 1990s, but goes up and down with small variation. Based on the reasons above, analysis in this current paper will not distinguish respondents’ graduation cohorts. Variation across different time periods is less of a research interest than the skill transferability of STEM and contextual knowledge requirement of non-STEM fields, both of which are not highly subjected to changes over time.
paper I argue that the chance of switching from a STEM field to a prestigious non-STEM field is lower for foreign educated immigrants than natives.

The case of foreign-college educated immigrants illustrates the disadvantages attached both to a foreign college degree and to immigrant status. These disadvantages may reduce the likelihood that immigrants switch from STEM to non-STEM advanced degrees, or even increase the likelihood that immigrants with a non-STEM degree pursue advanced training in science. First, as the number of natives entering or retaining in STEM fields declines, the U.S. labor market pulls more immigrant STEM students to occupy the positions left by natives. Second, STEM skills transfer easily across countries, because these fields share fundamental paradigms, knowledge structure and quantitative methods (Tang 2000). Moreover, because of the similarity of knowledge in STEM fields across countries, immigrants tend to believe that STEM fields are more universal and STEM knowledge can be transferred with comparatively small amount of loss of their pre-immigration human capital. The “Science universalism belief” (Xie and Killeward 2012, Tang 2000) is one of the perceptions more often held by disadvantaged social groups. This belief includes the notion that scientific work is judged in terms of merit alone, and the notion that science recruits its members on the basis of talent as opposed to functionally irrelevant factors such as race, gender, nationality, religion, and social origin. Because citizenship status and place of education can be disadvantaged social characteristics, immigrants may worry that they will be judged negatively in the less “universal” non-STEM fields. Such beliefs may prevent immigrants from switching to non-STEM fields, even when these fields may be easier to pursue or more profitable. For
immigrants in certain STEM fields who intended to pursue a more profitable field, science universalism beliefs may lead them to another field within STEM than to a non-STEM field.

Hypothesis 1.1: Foreign college-educated immigrants with a STEM degree have a higher probability to retain in STEM fields when entering a U.S. graduate school than their native U.S. college-educated counterparts.

In addition to a general observation that immigrants are more likely to concentrate in STEM fields, evidence suggests that there is less gender segregation in field of study among immigrant sending countries. Charles and Bradley (2002; 2009) show that, due to ideology of expressive choices, many economically developed countries encourage the sex typing of educational dispositions and career expectations which enhance gender stereotyping. Freedom of choice in college majors and curricula in these countries pulls female students away from traditional male typed fields, namely STEM fields that they do not “feel interested in” or competent in, under the guise of self-expression. These studies reveal an important negative relationship between the level of economic development and gender segregation within a country’s higher education system. More structural responses to the higher gender parity in developing contexts are also available. Gerber and Schaefer (2004) studied pre-reform Russia and found that the country placed heavy emphasis on the STEM fields in that they may be more central to the economic development. As a result, the hard sciences had larger student populations and more
financial support from the government for longer periods of time. This opportunity structure, which is shared by many other developing societies and immigrant sending countries, does not discriminate against females. In response to these studies, the current study assumes that foreign college-educated female immigrants not only have a higher probability to retain in STEM, but are also more likely to have a STEM undergraduate degree than native U.S. educated females.

*Hypothesis 1.2: Foreign college-educated females have a higher probability to major in STEM than native females, and a higher probability to retain in STEM fields when entering a U.S. graduate school than native female STEM students.*

**Contextual Knowledge, Credentialing and Low Transferability of Professional Fields**

Contrary to structural openings and higher skill transferability in STEM fields, immigrants face obstacles when applying for a non-STEM field in the U.S. As Tang (2000) noted, immigrants have less cultural capital in the form of English language, credentials, and knowledge of specific labor market practices that matters in the U.S. labor market. Whether these factors become obstacles for immigrants to enter prestigious non-STEM fields is yet to be tested. While most existing literature focuses on immigrants’ high rate of retention in STEM fields, the current study seeks to examine the broader structure of field of study and determine whether the increasing opportunities
outside of STEM draw students away from STEM, and whether immigrants are less able to seize these opportunities due to a lack of contextual knowledge and credentials.

From a human capital perspective, a four-year U.S. college education offers enormous contextual knowledge to both natives and U.S. educated immigrants (Chiswick, Lee and Miller 2005). Students in fields that are based on knowledge specific to the context, such as law and business, may acquire qualitatively different trainings in two different places of education. For example, legal training is not directly offered in U.S. colleges at undergraduate level, but is offered in countries like China and India. Instead, U.S. educated students receive pre-law education in fields such as political science, history or sociology. Such pre-law education is highly specific to the history, society and legal system of the U.S., making a foreign law training much less compatible when entering a graduate or professional school. In the U.S., pre-law education may also offer opportunities for practice, participation and observation through internships and co-ops that endow students with a solid understanding of how a profession operates locally. Even for non-professional fields like humanities and the social sciences, time spent in a U.S. educational institution improves students’ language and acculturates them in numerous ways.

From a social closure perspective (Sorensen 2000, Weeden 2002), several contextually specific fields restrict entrance and limit the number of students enrolled so that higher rent can be generated for those who attained a degree. This is especially evident in law and medicine. As higher rent is maintained, or higher market rewards of these fields are created, the competition for study places is further intensified, which in
turn signals the higher economic and social capital of people who succeeded in attaining such degrees (Reimer, Noelke and Kucel 2008). Furthermore, to acquire a job in professional fields, students have to go through lengthy credentialing and licensing processes that are specific to the U.S. context. These processes add to the opportunity and psychological costs for those who were trained abroad. Some researchers (Kugler and Sauer 2005) found that if outside opportunities are available, foreign trained talent may seek employment in a different field rather than their initial field in order to avoid the cost of credentialing or licensing process. Yet their decision to switch field need not happen only after they graduated: they may also switch to another field in graduate school before they enter the labor market.

The human capital and social closure perspectives therefore suggest that natives should have better access to opportunities emerging in prestigious non-STEM fields. Increasing enrollments in these fields thus pull more native students, both from STEM majors and non-STEM majors to attain advanced training. However, a switch in the opposite direction may be observed among foreign educated immigrants who initially majored in these prestigious non-STEM fields. Foreign college-educated immigrants holding degrees in these fields should suffer the biggest skill discount when transferring. If their previous training is not compatible with U.S. law, medicine or business training traditions, they may not even be admitted to a U.S. graduate school in the first place. This fact may provide them the motivation to switch to a field that is comparatively prestigious, less contextual and still in need of skilled workers: a STEM field.
Thus relative to native U.S. college-educated students, when entering a U.S. graduate school:

*Hypothesis 2.1:* Foreign college-educated immigrants with a STEM degree have a lower probability of switching into a non-STEM field.

*Hypothesis 2.2:* Foreign college-educated immigrants with a STEM degree have a lower probability of switching into law, medicine or business.

*Hypothesis 3:* Foreign college-educated immigrants with a non-STEM degree have a higher probability of switching into STEM fields.

**Gaining Contextual Knowledge: Assimilation and U.S. Educated Immigrants’ Field of Study**

Contextual knowledge is by no means static. It can be gained actively through acculturation, which facilitates immigrants’ entrance to contextually specific fields. Time spent in the U.S. is generally regarded as a positive factor for acculturation according to classical assimilation theory, ethnic pluralism theory, human capital theory, segmented assimilation theory and ethnic stratification theory (Redstone and Massey 2004). On the other hand, time of arrival, which is closely related to the length of stay, is an independent factor that contributes to assimilation. As Painter (2013) illustrated, a given number of years in the United States may result in greater gains for immigrants who arrived as children than immigrants who arrived as adolescents or adults, because they
are more likely to learn English at a younger age, attend school and complete their
education in the U.S. school system.

Both length of stay and time at arrival should benefit an immigrant’s language
acquisition. Since foreign college-educated immigrants usually immigrated at the same
time they were admitted to a U.S. educational institution, there’s virtually no gap between
their arrival and their entrance into the education system. But for U.S. college-educated
immigrants, there can be an ample period to gain contextual knowledge and improve
English before they enter higher education.

U.S. educated immigrants differ from their foreign educated counterparts in the
indicators of assimilation mentioned above. Thus I expect that during the process of
acculturation, U.S. educated immigrants may gradually gain contextual knowledge and
their educational pathways may resemble the educational pathways of natives. I
hypothesized in previous sections that natives are more likely to switch from STEM to
professional fields, which is a route that U.S. educated immigrants may follow. But the
switch to professional fields does not have to be limited to the STEM students. It is well
known that liberal arts majors and social science majors also provide basic trainings for
professional school, as is evidenced by the frequent transition from political science to
law. Thus if there is an effect of assimilation, relative to foreign educated immigrants,
U.S. educated immigrants should have a greater possibility of entering professional fields
than foreign educated immigrants either from STEM or non-STEM fields. In this paper, I
draw from previous research (Portes and Zhou 1993, Redstone and Massey 2004, Alba
2004) and consider four dimensions of acculturation: a U.S. college degree, English
proficiency, age at immigration, and length of stay in the U.S. The importance of a U.S. college degree is addressed by separating the U.S. educated immigrants from the foreign educated ones. For the other three dimensions, the corresponding hypothesis is:

*Hypothesis 4: For U.S. college-educated immigrants, longer years of stay, younger age at immigration and better English ability increase their probability of switching to a professional field either from a STEM field or a non-STEM field.*
Data and Method

The 2003 National Survey of College Graduates (NSCG 2003) is used to examine the field switching patterns among natives, U.S. educated immigrants and foreign educated immigrants. NSCG 2003 sampled recipients of a bachelor’s degree or higher degree in any field of study prior to April 2000, using the 2000 decennial census long form as the sampling frame.

The original NSCG 2003 has a sample size of 100,402 college graduates. It is trimmed into a smaller sample which contains only college graduates who proceeded to graduate school and attained their highest degree in the U.S. It includes three groups of college graduates: U.S. born, U.S. college-educated students who also attained their graduate degree in the U.S. (hereafter “natives”), foreign born, U.S. college-educated students who attained their graduate degree in the U.S. (hereafter “UE immigrants”), and foreign born, foreign college-educated students who attained their graduate degree in the U.S (hereafter “FE immigrants”). Adding place of education to the native-immigrant comparison makes it possible to examine the heterogeneity among immigrants. UE immigrants, who possess both the advantages of being educated in a U.S. college and the

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5 Starting from 2010, NSCG uses the American Community Survey (ACS) as sample frame, because the census long form has been discontinued. NSCG 2010 selects a portion of its sample from the 2009 American Community Survey respondents who indicated to have a bachelor's degree or higher in any field of study and keeps a portion from NSCG 2008, a subsample of NSCG 2003 who were followed throughout the decade. Due to the difference in sample frames, this study uses the 2003 cycle instead of the newest 2010 one, in order to speak more directly to the existing literature which mostly used the 2003 cycle.
disadvantages attached to their immigrant status, can serve as an effective sample to test the assimilation theory raised by hypothesis 4. Natives who had a foreign college degree and immigrants who attained both college and graduate degree in their home countries are not included in the sample. Keeping only college graduates who attained their final degree in the U.S. ensures the comparability of immigrants and natives, and at the same time ensures that all respondents underwent the college-graduate school transition in the same context. The final operational sample contains 41,102 persons, among which 33,545 are natives, 3,558 are UE immigrants, and 3,999 are FE immigrants. Male respondents take up 56% of the sample. There are 2,626 respondents in the original sample missing both place of their first bachelor’s degree and place of their highest degree. They are excluded from the analysis.

NSCG 2003 offers information about college graduates’ place of education and field of study at each level of tertiary education attained. Multiple demographic characteristics of the respondents and their parents are also available.

Field of study: There are 143 majors within 28 fields in the dataset, but for the efficiency of analysis, I aggregate them into 9 categories: engineering, biology/life/agricultural sciences, math and computer sciences, physics and chemistry, social sciences, law, medicine, business, and all others. This categorization highlights the three professional fields: law, medicine, and business, which are seldom specified in previous studies. Switching field of study is defined as having different fields of study at first bachelor’s level and highest level. Place of education: Place of college degree and

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6 See Appendix B for how the 143 majors were categorized into 9 fields.
highest degree can be obtained from a question asking the respondent’s location of school awarding first bachelor’s degree (the same question is asked for highest degree), which has a binary answer of “U.S.” and “non-U.S.” Only those who answered “U.S.” for highest degree were kept in the sample. **Level of education:** Respondents’ highest level of education was coded as a 4 year college degree, Master’s, professional and PhD degrees. If the highest level of education for a respondent is a 4 year college degree, he or she is excluded from the analytical sample. **Nativity:** Natives are defined as respondents born in the U.S. or born abroad to American parents. Immigrants are respondents who were foreign born, regardless of whether they are naturalized or not. **Assimilation indicators:** Age at immigration is captured by a question asking “In what year did you first come to the United States for six months or longer?” It is centered on year 1940 in this study. Length of stay is calculated by year started college minus age at immigration. Hispanics, Asians and African Americans are identified by dummy variables. In addition, father’s education is measured at 6 levels: less than high school, high school, some college, bachelor’s, master’s, professional and doctorate. One major drawback of this dataset, as in many other immigrant-related datasets, is that it doesn’t contain indicators of language proficiency. Command of English is both a way to assimilate and an indicator of assimilation. It is supposed to facilitate immigrants’ entrance to contextually specific fields of study such as law and business. To account indirectly for the language effect when testing the assimilation theory, I adopt Espenshade and Fu’s (1997) measurement of English proficiency by region. The regions of immigrants were categorized into English dominant countries, English as official language countries, Spanish speaking
countries, Asian languages speaking countries, Arabic languages speaking countries, and European, African and all other languages speaking countries.

Analysis is conducted in two steps. First, I use log-linear models to address the patterns in the first 3 hypotheses. Although not able to incorporate or control for continuous variables, Log-linear models are sufficient to identify the associations between field of study of the first bachelor's degree and that of the highest degree, independent of the marginal distributions of the number of students by origin and destination fields. The 9 fields of first bachelor’s degree serve as the columns of a contingency table, and 9 fields of highest degree serve as the rows. This table will be further divided by nativity, place of education and gender. Nativity and place of education are combined into a three-value variable coded as 0 for U.S. educated natives, 1 for UE immigrants and 2 for FE immigrants. Based on gender and nativity/place of education, 6 different 9x9 tables can be created.

Retaining in a field may be the dominant pattern when transitioning from college level to graduate level. As a result, I create a series of “retention parameters” to denote cells along the main diagonals. To capture the nativity/place of education differences in field switching patterns, I add interaction terms between the nativity/place of education identifier and the retention parameters. Interactions denoting gender effects can then be added in the same way. After creating parameters to specify retention patterns, I create a set of parameters indicating whether the person switched from a STEM field to a non-STEM field, whether the person switched from a non-STEM field to a STEM field, and
whether a person switched within the STEM fields. These three sets of parameters are interacted with nativity/place of education identifier and gender, as in the analysis of retention patterns.

In addition, the literature reviewed previously suggests that males and females, as well as natives, UE immigrants and FE immigrants may concentrate in different undergraduate fields when they start off. To take into account the nativity/place of education and gender differences in the marginal distribution in first bachelor’s degree, the nativity/place of education identifier and gender are interacted with the parameter for marginal distribution of first bachelor’s degree.

According to the description above, the model is specified as follow:

\[
\log F_{ijkh} = \beta_0 + \beta^B_i + \beta^H_j + \beta^K_k + \beta^N_i + \beta^{BF}_i + \beta^{BFN}_i + \beta^{BFNG}_i + \beta^P_j + \beta^{NP}_j + \beta^{GP}_j + \beta^{NGP}_{ijkh} \tag{1}
\]

where \( F_{ijkh} \) is the expected number of people who start from field \( i \) and end up in field \( j \) of nativity/place in education group \( k \) and gender \( h \). \( \beta_0 \) is the constant; \( \beta^B_i \) is the person’s bachelor’s degree field (\( i \) ranges from 0 to 8, denoting the 9 fields); \( \beta^H_j \) is the person’s highest degree field (\( j \) ranges from 0 to 8). Nativity/place of education is denoted by \( \beta^K_k \) (\( k \) ranges from 0 to 2). Gender is denoted by \( \beta^G_h \) (\( h=0 \) or 1). \( \beta^{BFN}_i \) accounts for the marginal differences of first bachelor’s degree fields among different nativity/place of education groups, and \( \beta^{BFG}_i \) accounts for the marginal differences of first bachelor’s degree fields between men and women. \( \beta^{BFNG}_{ijkh} \) is the three-way interaction.

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7 For example, if the column value for a person equals “0 engineering” while the row value equals “7 business”, then this person will get a “1” in a dummy created for this specific route from engineering to business.
between $i, k$ and $h$. $\beta_{ij}^P$ is a set of dummies denoting the field switching patterns, which get a value of 1 if the person switched from field $i$ to field $j$ (namely, falls in a certain cell(i,j)), and 0 if not. If $i$ equal $j$, the person retains in the field. Other components in the model are two-way interaction between nativity/place of education and field switching patterns ($\beta_{ijk}^{NP}$), two-way interaction between gender and field switching patterns ($\beta_{ijh}^{GP}$), and three-way interaction among switching patterns, nativity/place of education identifier and gender ($\beta_{ijkh}^{NGP}$).

After depicting the pattern of field switching among different subgroups, the U.S. college-educated immigrants will be modeled by logistic regression to see if the assimilation indicators play a part in their choices of graduate field of study. The choice will be recoded into a binary variable (0 “did not switch to law, medicine or business” and 1 “switched to law, medicine or business”). The expectation is that the higher their assimilation indicators (younger age at immigration, longer years of stay and higher English proficiency), the higher the probability of switching to law, medicine or business.
Results

Descriptive Statistics

Table 1 drawn from the data suggests a strong pattern for FE STEM students to retain in the STEM fields in graduate school. At the bachelor’s degree level, there has already been a large difference in the percentage of students majoring STEM between FE immigrants and natives. 69.9% of the former group has a STEM college degree, while only 32.5% of the latter has it. At the graduate level, the retention rate for FE immigrants in STEM is 85.8% (60.0% / 69.9%), while it is only 57.8% (18.8% / 32.5%) for natives.

<table>
<thead>
<tr>
<th></th>
<th>Sample Size</th>
<th>Bachelor’s degree in STEM (%)</th>
<th>Bachelor’s and Highest degree both in STEM (%)</th>
<th>% retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natives</td>
<td>33,545</td>
<td>10,899 (32.5%)</td>
<td>6,295 (18.8%)</td>
<td>57.8%</td>
</tr>
<tr>
<td>UE immigrants</td>
<td>3,558</td>
<td>1,791 (50.3%)</td>
<td>1,130 (31.8%)</td>
<td>63.1%</td>
</tr>
<tr>
<td>FE immigrants</td>
<td>3,999</td>
<td>2,794 (69.9%)</td>
<td>2,401 (60.0%)</td>
<td>85.8%</td>
</tr>
</tbody>
</table>

Table 1 Distribution of Field of Study at Highest Level According to First Bachelor’s Degree Among Natives, U.S. College-educated Immigrants and Foreign College-educated Immigrants.
Table 2 and 3 decompose the switch from one particular STEM field to other fields (another STEM field, law, medicine or business, or non-STEM non-professional fields) for males and females respectively. Engineering is a typical example that properly illustrates the general pattern for males in table 2. 42.4% (1450/3423) of native engineering students switched their field in graduate school, while only 32.0% (248/756) of UE engineering students and 30.8% (407/1323) of FE engineering students did so. Among engineering students who switched, the destinations also vary substantially among the three groups. The percentage of students who switched to the three professional fields (law, medicine and business) is 69.7% for native engineering students, 65.3% for UE engineering students, and only 37.3% for FE engineering students. On the other hand, for FE engineering students, 55.0% switched within STEM fields (to biology, math/CS or physics/chemistry), which largely surpasses the other two groups. 23.4% of UE engineering students, and only 17.9% of native engineering students switched within STEM. A similar pattern can be observed in physics and chemistry, where 84.9% of the switches happened within STEM for FE students, and only 41.5% for natives. On the contrary, 41.6% native physics/chemistry students were able to switch to a professional field, but only 10.1% of their FE counterparts did so.
<table>
<thead>
<tr>
<th></th>
<th>Number of students at B.A. level (1)</th>
<th>Number of students switched (2)</th>
<th>Switched to Another STEM field (3)</th>
<th>Law, Med, Business (4)</th>
<th>Non-STEM, Non-professional (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natives</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>3,423</td>
<td>1,450</td>
<td>260</td>
<td>1,010</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17.9%</td>
<td>69.7%</td>
<td>12.4%</td>
</tr>
<tr>
<td>Bio/life</td>
<td>1,943</td>
<td>1,296</td>
<td>119</td>
<td>908</td>
<td>269</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9.2%</td>
<td>70.1%</td>
<td>20.8%</td>
</tr>
<tr>
<td>Math/CS</td>
<td>1,037</td>
<td>509</td>
<td>100</td>
<td>260</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>19.6%</td>
<td>51.1%</td>
<td>29.3%</td>
</tr>
<tr>
<td>Phy/Chem</td>
<td>1,719</td>
<td>890</td>
<td>369</td>
<td>370</td>
<td>151</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>41.5%</td>
<td>41.6%</td>
<td>17.0%</td>
</tr>
<tr>
<td><strong>UE immigrants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>756</td>
<td>248</td>
<td>58</td>
<td>162</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>23.4%</td>
<td>65.3%</td>
<td>11.3%</td>
</tr>
<tr>
<td>Bio/life</td>
<td>237</td>
<td>167</td>
<td>9</td>
<td>122</td>
<td>36</td>
</tr>
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<td></td>
<td>5.4%</td>
<td>73.1%</td>
<td>21.6%</td>
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<tr>
<td>Math/CS</td>
<td>165</td>
<td>65</td>
<td>23</td>
<td>25</td>
<td>17</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>35.4%</td>
<td>38.5%</td>
<td>26.2%</td>
</tr>
<tr>
<td>Phy/Chem</td>
<td>177</td>
<td>92</td>
<td>48</td>
<td>31</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>52.2%</td>
<td>33.7%</td>
<td>14.1%</td>
</tr>
<tr>
<td><strong>FE immigrants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>1,323</td>
<td>407</td>
<td>224</td>
<td>152</td>
<td>31</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>55.0%</td>
<td>37.3%</td>
<td>7.6%</td>
</tr>
<tr>
<td>Bio/life</td>
<td>177</td>
<td>55</td>
<td>33</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>60.0%</td>
<td>16.4%</td>
<td>23.6%</td>
</tr>
<tr>
<td>Math/CS</td>
<td>241</td>
<td>57</td>
<td>27</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>47.4%</td>
<td>28.1%</td>
<td>24.6%</td>
</tr>
<tr>
<td>Phy/Chem</td>
<td>346</td>
<td>139</td>
<td>118</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>84.9%</td>
<td>10.1%</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

Notes: The counts in column (3), (4) and (5) add up to the count in column (2). The percentages in column (3), (4) and (5) add up to 100%

Table 2 Breakdown of male STEM bachelors who switched fields at highest level of education, by place of education and nativity.
In table 3, the general pattern for females is similar to that found for males: among females, FE STEM students have the lowest percentage of switching to the three professional fields, but the highest percentage switching within-STEM. Their general rate of switching is also much lower than that of natives or UE immigrants. The findings presented in Table 2 and 3 provide evidence that natives and immigrants are channeled into different structural positions in the U.S. educational system, and that immigrants are less likely to access other high status fields than the STEM ones. However, some distinctions are smaller for females than for males. In biology, the percentage male students switching to professional fields (mostly medicine) is 70.1% for natives, 73.1% for UE immigrants, and 16.4% for FE immigrants. But the numbers for female biology students who switched to professional fields are 53.7%, 56.0% and 21.8% for natives, UE immigrants and FE immigrants accordingly. Some of the patterns are less consistent for females compared to males. For example, of UE females who majored in physics/chemistry an even lower percentage (26.2%) switch to another STEM field than native females who majored in physics/chemistry (41.8%), though both of the percentages are much lower than FE females (77.5%).
<table>
<thead>
<tr>
<th>Place of Education</th>
<th>Field</th>
<th>Natives</th>
<th>UE immigrants</th>
<th>FE immigrants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of students at B.A. level</td>
<td>Number of students switched</td>
<td>Switched to</td>
<td>Another STEM field</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18.3%</td>
<td>67.8%</td>
</tr>
<tr>
<td>Natives</td>
<td>Engineering</td>
<td>504</td>
<td>208</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>Bio/life</td>
<td>1,223</td>
<td>787</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Math/CS</td>
<td>547</td>
<td>300</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Phy/Chem</td>
<td>503</td>
<td>294</td>
<td>123</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>41.8%</td>
<td>32.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8.9%</td>
<td>53.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17.0%</td>
<td>43.3%</td>
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<tr>
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<td></td>
<td></td>
<td>13.9%</td>
<td>67.8%</td>
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<td>38.0%</td>
<td>56.0%</td>
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<td>38.0%</td>
<td>56.0%</td>
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<tr>
<td></td>
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<td></td>
<td>39.7%</td>
<td>43.3%</td>
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<td>35.0%</td>
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<td></td>
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<td>42.5%</td>
<td>26.2%</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>34.5%</td>
<td>40.5%</td>
</tr>
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<td>35.5%</td>
<td>41.9%</td>
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<tr>
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<td>42.6%</td>
<td>33.3%</td>
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<td>22.5%</td>
<td>41.9%</td>
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<td></td>
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<td>17.0%</td>
<td>14.1%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>6.6%</td>
<td>8.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>19.0%</td>
<td>19.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>34.5%</td>
<td>34.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22.6%</td>
<td>22.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>77.5%</td>
<td>77.5%</td>
</tr>
</tbody>
</table>

Notes: The counts in column (3), (4) and (5) add up to the count in column (2). The percentages in column (3), (4) and (5) add up to 100%.

Table 3 Breakdown of female STEM bachelors who switched fields at highest level of education, by place of education and nativity.
The descriptive statistics for field switching patterns do not account for the marginal distribution of natives/UE immigrants/FE immigrants or males/females in a certain field. In the previous example, percentage switching from physics/chemistry to another STEM field for UE females is very low due to an exceptionally small number of them majoring physics/chemistry at undergraduate level in the first place. Therefore, log-linear models are applied to cross-classified data of college graduates’ first bachelor’s degree field and highest degree field so as to control for the marginal distributions at the two levels. At the same time, this strategy isolates the independent effects of nativity, place of education and gender on each field switching pattern.

*Model fitting*

The model fitting process seeks to find a model that best explains the variability in the cross-classified data, which is to say that the model should bring a smallest BIC statistic compared to other models. Table 4 shows the likelihood-ratio chi-square statistics, degree of freedom and BIC statistics for selected models of field switching patterns fitted to cross-classified data. The baseline model includes only the marginal distribution of first degree field and highest degree field. As can be seen from the statistics, the predicted counts of this model cannot reproduce the observed data. The poor fit by likelihood-ratio statistics and BIC indicates that variables have to be added in order to explain the variability in the table. The second model adds two interactions: one between the distribution of first degree field and nativity/place of education, and the other
between the distribution of first degree field and gender. As expected, the distribution of people’s first bachelor’s degree field differs between males and females, and among natives, UE immigrants and FE immigrants. The added parameters significantly decrease the BIC statistic from 104,330 to 54,564. However, the three way interaction (model 2) of bachelor’s field distribution, gender and nativity/place of education is not significant and increases the BIC statistic instead, suggesting that FE females are not more likely than UE or native females to major in STEM at undergraduate level. This rejects the part of hypothesis 1.2 that assumes FE females have a higher probability to major in STEM at undergraduate level than native females. The other part that assumes FE females have a higher probability to retain in STEM will be test next.

After controlling for the marginal distributions (model 1), the next step is to identify field switching patterns and reveal how they differ among natives, UE immigrants and FE immigrants. The first set of parameters added to the model specifies the retention patterns, its interaction with nativity/place of education (model 3, based on model 1 rather than model 2) and its interaction with gender (model 4). BIC statistics are again significantly reduced, indicating that retention patterns explain a large portion of the variability in the table. Nativity/place of education and gender both make a difference in retention patterns, although gender’s effect is not as large as nativity/place of education according to the BIC statistic.

Model 5 takes into account three-way interactions of gender, nativity and retention patterns. However, the BIC statistic indicates that it does not improve the model fit compared to model 4, where only the two-way interactions are included. Almost all
coefficients of the three-way interaction are not significant, thus further rejecting the other half of hypothesis 2.1 that FE female immigrants are more likely than native or UE females to retain in STEM fields. The three way interactions for other field switching patterns are also not significant, as indicated in model 10. In model 10, neither the STEM to non-STEM switch nor the within-STEM switch differs between FE females and other groups. In this sense, newer parameters were added to the previous best-fitting model. For example, as model 3 adds new parameters to model 1, model 6 adds parameters to model 4, and model 11 adds parameters to model 8. All are highlighted in table 4.

Thus based on model 4, model 6 adds the parameters of switching from a STEM field to a non-STEM field. Routes from a STEM field to a professional field are included in this set of parameters. Model 7 adds the parameters of switching within STEM fields, which reduces the BIC statistic below zero (-1,150). This model is an even better fit than a saturated model that includes all possible two-way and three-way interactions (where BIC=0).

Model 8, 9 and 10 add two-way and three-way interactions of gender to previous models. The BIC statistic steadily increases, which again refutes the assumption that FE females are different from other groups in switching from STEM to non-STEM, or switching within STEM. However, although model 8 is no better than model 7 in terms of fit, the next model, model 11 is based on model 8, instead of model 7. This is because BIC penalizes number of parameters in the model. The 20 new parameters that model 8 adds to model 7 raises its BIC above that of model 7. However, many of these parameters
are significant and show important differences between males and females in transitioning to these routes, thus model 8 is chosen over model 7.

Models 11, 12 and 13 examine whether parameters specifying non-STEM to STEM switches improve model fit. When interacted with nativity, the set of parameters in model 11 reduces BIC to -1,351, but further adding interactions with gender (model 12) and three-way interaction (model 13) does not improve the model fit.

<table>
<thead>
<tr>
<th>Models</th>
<th>L squared</th>
<th>df</th>
<th>BIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline model: field1 + field2</td>
<td>109,313</td>
<td>469</td>
<td>104,330</td>
</tr>
<tr>
<td>m1 =Baseline model + field1<em>nat+field1</em>fem</td>
<td>59,260</td>
<td>442</td>
<td>54,565</td>
</tr>
<tr>
<td>m2 =m1+field1<em>nat</em>fem</td>
<td>59,196</td>
<td>424</td>
<td>54,691</td>
</tr>
<tr>
<td>m3 =m1+retention<em>retention</em>nat</td>
<td>12,887</td>
<td>415</td>
<td>8,478</td>
</tr>
<tr>
<td>m4 =m3+retention*fem</td>
<td>12,640</td>
<td>406</td>
<td>8,327</td>
</tr>
<tr>
<td>m5 =m4+retention<em>nat</em>fem</td>
<td>12,572</td>
<td>386</td>
<td>8,471</td>
</tr>
<tr>
<td>m6 =m4+SN+SN*nat</td>
<td>4,474</td>
<td>352</td>
<td>734</td>
</tr>
<tr>
<td>m7 =m6+WI+WI*nat</td>
<td>2,271</td>
<td>322</td>
<td>-1,150</td>
</tr>
<tr>
<td>m8 =m7+SN*fem</td>
<td>2,132</td>
<td>304</td>
<td>-1,097</td>
</tr>
<tr>
<td>m9 =m8+WI*fem</td>
<td>2,089</td>
<td>294</td>
<td>-1,034</td>
</tr>
<tr>
<td>m10 =m9+SN<em>nat</em>fem+WI<em>nat</em>fem</td>
<td>1,983</td>
<td>232</td>
<td>-482</td>
</tr>
<tr>
<td>m11 =m8+NS+NS*nat</td>
<td>1,283</td>
<td>248</td>
<td>-1,351</td>
</tr>
<tr>
<td>m12 =m11+NS*fem</td>
<td>1,196</td>
<td>228</td>
<td>-1,226</td>
</tr>
<tr>
<td>m13 =m12=NS<em>nat</em>fem</td>
<td>1,136</td>
<td>186</td>
<td>-840</td>
</tr>
</tbody>
</table>

Notes: “field1” means bachelor’s field, and “field2” means the highest degree field. “nat” means nativity/place of education identifier, and “fem” means the gender dummy. “retention” denotes the diagonal parameters, where persons whose first bachelor’s degree field is the same as their highest. “SN” denotes STEM to non-STEM transitions, flagging people whose first bachelor’s degree field is STEM but highest degree field is non-STEM. “NS” is opposite to “SN”, flagging people who switched from a non-STEM bachelor’s field to a STEM one at highest level. “WI” denotes within-STEM switches, flagging people who were in one of the four STEM fields and switched to another at highest educational level. New parameters are added to the previous best fitting model (m3 based on m1 rather than m2; m6 based on m4 rather than m5), except for m11, which adds new parameters to m8 rather than m7. Reasons are explained in the model fitting part.

Table 4 Log-linear models of field switching patterns, nativity/place of education and gender.
Results

The preceding modeling process suggests that much of the association in the cross-classified data can be attributed to the significant statistical association among nativity/place of education, gender and a certain postgraduate trajectory (retain in STEM, switch from STEM to non-STEM, switch within STEM or switch from non-STEM to STEM). Model 11 is comparatively parsimonious and gives the smallest BIC statistic, thus is preferred as a model for interpretation.

Table 5 presents the probability of retaining in a certain STEM field for UE immigrants and FE immigrants compared to natives. According to the odds ratios, UE immigrants do not significantly differ in their probability of retaining in STEM from natives, but noticeable differences appear between FE immigrants and natives. FE immigrants have 2.56 times the probability of retaining in engineering, and 2.28 times the probability of retaining in physics and chemistry compared to natives. They also have 96% higher probability of retaining in math and computer sciences compared to natives, but the result is significant at the p<0.1 level. There is no significant difference in retaining in biology related fields (biology, agricultural sciences and life sciences) between FE immigrants and natives. This is probably because native biology students and FE biology students differ more in their chances of switching to medical school than retaining in biology, which will be tested in a moment. In general, the results in table 5 support hypothesis 1.1 that FE immigrants with a STEM degree have a higher probability of retaining in their undergraduate field than native STEM students.
In addition, the last row of table 5 presents gender differences in retaining in STEM fields. Since a three-way interaction between retention, gender and nativity/place of education failed to improve model fit, no distinction between nativities or places of education is made in this row. According to these results, females are 34% less likely to retain in engineering, but no less likely than males to retain in the other three fields.

<table>
<thead>
<tr>
<th></th>
<th>Engineering</th>
<th>Biology, Agricultural Sciences and Life Sciences</th>
<th>Math and Computer Sciences</th>
<th>Physics and Chemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td>UE immigrants relative to natives</td>
<td>1.63 (0.49)</td>
<td>1.44 (0.58)</td>
<td>1.19 (0.50)</td>
<td>1.43 (0.45)</td>
</tr>
<tr>
<td>FE immigrants relative to natives</td>
<td>2.56** (0.72)</td>
<td>1.18 (0.32)</td>
<td>1.96+ (0.77)</td>
<td>2.28** (0.59)</td>
</tr>
<tr>
<td>Females relative to males</td>
<td>0.66** (0.07)</td>
<td>1.10 (0.15)</td>
<td>1.02 (0.16)</td>
<td>0.83 (0.08)</td>
</tr>
</tbody>
</table>

Notes: + \( p \leq 0.1 \), * \( p \leq 0.05 \), ** \( p \leq 0.01 \), two-tailed tests. Standard errors of the coefficients are in the parentheses. The three-way interaction is not significant among retention, gender and nativity/place of education, thus the first two rows presents the nativity/place of education difference without distinguishing gender, and the last row presents the gender difference without distinguishing nativity/place of education.

Table 5 Odds ratios of retaining in a STEM field for U.S. college-educated immigrants and foreign college-educated immigrants relative to natives.

Figure 1 illustrates pathways from a STEM field to a non-STEM field, including a professional field. There are 20 routes of STEM to non-STEM switches in total. Figures 1
presents all routes for which FE immigrants and natives have significantly different chances of entering. Among these routes, the UE-native differences are mostly not significant except for the switch from biology to medicine and the switch from biology to social sciences.

Figure 1 Odds ratios of switching out of STEM for U.S. college-educated immigrants and foreign college-educated immigrants relative to natives.

Notes: All FE-native differences are significant at .05 or .01 level, two-tailed tests. The UE-native differences are not significant, except for biology-medicine switch and biology-social sciences switch, as noted in the figure. Insignificant routes that are not presented in the figure include: engineering to medicine, engineering to business, biology to law, math to law, math to medicine, math to business, physics to law, physics to business, engineering to social sciences, engineering to all others, math to social sciences, physics to social sciences.
Corresponding to hypothesis 2.1 and 2.2, the expectation is that FE immigrants are less likely to switch out of STEM field to a non-STEM field because of a lack of contextual knowledge and credentials, and that they are more likely to make within-STEM switches because of high transferability and the science universalism belief. According to figure 1, eight routes are significantly different between FE immigrants and the other two groups: engineering to law, biology to medicine, biology to business, physics to medicine, biology to social sciences, biology to all others, math to all others, and physics to all others. Of special interest are the first four routes: all destinations are professional fields, and the odds ratios in these four routes are especially small for FE immigrants. Most noticeably, the seemingly common switch between biology and medicine is uncommon for FE immigrants: they are 95% less likely to switch from biology to medicine compared to natives. Based on the evidence, the two hypotheses are largely confirmed: FE immigrants have a lower probability of switching to a non-STEM field, especially to a professional field. On the other hand, UE immigrants are not very different from natives in their STEM to non-STEM switches. What’s more, they are much more likely to switch from biology to medicine compared to natives. The reason for this requires further investigation.

These results indicate that it is harder for FE immigrants to enter professional fields from a STEM field. A more direct illustration of this finding is presented in figure 2, which shows the expected number of FE immigrants switching from STEM to a professional field relative to 1000 natives. The expected numbers are generated from multiply the odds ratio for FE students to enter a route relative to native students by 1000.
The difference is dramatic: among 1000 natives who switched from biology to medicine, there are only 50 FE immigrants who could do the same. The number compared to 1000 natives switching from engineering to law, from biology to business and from physics to medicine is 90, 320 and 90 for FE immigrants respectively.

Figure 2 Expected number of foreign college-educated immigrants switching from STEM to a professional field relative to 1000 natives: four examples.

In addition to a lack of entrance into professional fields, there is smaller mobility between STEM and non-STEM fields among FE immigrants than among UE immigrants.
and natives. Even if FE immigrants switch their field of study in graduate school, they mostly do so within the STEM fields. According to figure 3, the chance for a FE immigrant to switch from engineering to math is 7 times that of a native, and the chance for a FE immigrant to switch from biology to math is 6 times that of a native. UE immigrants in all presented routes are not significantly distinguished from natives, but are nevertheless presented in figure 3 as a comparison.

Notes: All FE-native differences are significant at .05 or .01 level, two-tailed tests. The UE-native differences are not significant in all routes above. Insignificant routes that are not presented in the figure include: biology to engineering, biology to physics, math to engineering, math to biology, math to physics.

Figure 3 Odds ratios of switching within STEM for U.S. college-educated immigrants and foreign college-educated immigrants relative to natives.
Although not one of the hypotheses, the STEM to non-STEM switch is likely to differ between male and female according to the traditional science pipeline model, thus is also examined here. Results show that females are 36.8% less likely to switch from engineering to business compared to males. They are also 23.9% less likely to switch from biology to medicine compared to males. On the other hand, females are 80.9% more likely to switch out of biology, 85.2% more likely to switch out of math, and 71.3% more likely to switch out of physics/chemistry to a non-STEM, non-professional field compared to males.

Table 6 shows routes from a non-STEM field to a STEM field. Because such switches are much less frequently than those discussed previously, the cell numbers are very small. Law and medicine degrees at undergraduate level are not common among natives, thus the results should be treated with caution. In general, the results support hypothesis 3 that FE immigrants are more likely than natives to switch into STEM from a non-STEM field. UE immigrants, on the other hand, are more similar to natives in their chances of doing this type of switch. Here in table 6, FE students in medicine\(^8\) are more likely to switch back to biology, or switch to math. FE immigrants leaking out of medicine to a basic science field may indicate that the credentialing and gate-keeping in medicine is the strongest among all three professional fields, thus FE immigrants face the greatest obstacle to transfer their human capital to U.S. in medicine. Similarly, foreign educated immigrants are more likely than natives to switch from business to math,\(^8\)

\(^8\) These students come from origin countries where medicine is offered at bachelor’s level.
indicating that their previous education is less compatible with the business practices in the U.S. However, datasets of populations with a more balanced native-immigrant distribution in medicine and law are needed to substantiate the findings.
<table>
<thead>
<tr>
<th>Field Combination</th>
<th>UE Immigrants</th>
<th>FE Immigrants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio</td>
<td>Odds Ratio</td>
</tr>
<tr>
<td></td>
<td>(SE)</td>
<td>(SE)</td>
</tr>
<tr>
<td>Social sciences-engineering</td>
<td>0.55 (0.32)</td>
<td>2.95** (1.12)</td>
</tr>
<tr>
<td>Social sciences-math</td>
<td>1.57 (0.53)</td>
<td>10.50** (2.31)</td>
</tr>
<tr>
<td>Medicine-biology</td>
<td>2.33 (1.86)</td>
<td>8.75** (5.00)</td>
</tr>
<tr>
<td>Medicine-math</td>
<td>6.57e-07 (0.00)</td>
<td>21.00** (24.84)</td>
</tr>
<tr>
<td>Business-engineering</td>
<td>2.00 (0.91)</td>
<td>4.23** (1.99)</td>
</tr>
<tr>
<td>Business-math</td>
<td>1.68 (0.47)</td>
<td>9.28** (2.23)</td>
</tr>
<tr>
<td>All others-engineering</td>
<td>0.79 (0.34)</td>
<td>2.87** (0.86)</td>
</tr>
<tr>
<td>All others-biology</td>
<td>1.56 (0.44)</td>
<td>5.17** (1.13)</td>
</tr>
<tr>
<td>All others-math</td>
<td>1.24 (0.36)</td>
<td>5.68** (1.13)</td>
</tr>
<tr>
<td>All others-physics</td>
<td>0.21 (0.21)</td>
<td>3.53** (1.20)</td>
</tr>
</tbody>
</table>

Notes: * p ≤ 0.05, ** p ≤ 0.01, two-tailed tests. Standard errors of the coefficients are in the parentheses. All UE immigrants are not significantly different from natives, but are presented as a comparison. Insignificant routes that are not presented in this table include: social sciences to biology, social sciences to physics, law to business, law to biology, law to math, law to physics, medicine to engineering, medicine to physics, business to biology, business to physics.

Table 6 Odds ratios of switching from a non-STEM field to a STEM field for U.S. college-educated immigrants and foreign college-educated immigrants relative to natives.
To this point, the results suggest that UE immigrants are like natives than FE immigrants. Does assimilation contribute to their proximity to the patterns of natives? A dummy variable indicating whether a UE immigrant switched to a professional field from any other fields is the dependent variable, and logistic regression is employed to test the hypothesis. English dominant countries and countries using English as official language are given a “1” in the explanatory variable “language”, and other countries are given “0”. Of course, aggregate level measurement of language can be inaccurate when applied to individuals. But to reiterate, such an aggregate measurement will give a rough picture of whether command of English matters rather than to precisely decide which non-English speaking country has immigrants whose individual level English proficiency is higher.

Results show that immigrants' demographic characteristics play a part in their chance of switching to a professional field: older UE immigrants are less likely to switch to professional fields than younger ones; females are significantly less likely than males to switch to professional fields; Asian UE immigrants are more likely than White UE immigrants to switch to a professional field, net of other factors; UE immigrants whose father attained professional degrees are 50.6% more likely to switch to professional fields than those whose father had less than high school education. Other levels of father’s education increase the probability of switching professional fields, but are not significant. Assimilation factors also explain UE immigrants’ probability of switching to a professional field. UE immigrants from countries where English is the dominant or English is an official language have a 21.5% higher probability of switching to professional fields, and each year of later arrival decreases the probability of entering
professional fields by 3.3%. These results suggest that due to their assimilation, immigrants are able to follow the educational pathways of natives.
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Probability of entering a professional field</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Basic demographics</td>
<td>(2) Basic demographics + father’s level of education</td>
<td>(3) Basic demographics + father’s level of education + assimilation indicators</td>
</tr>
<tr>
<td>Age</td>
<td>0.98** (0.00)</td>
<td>0.98** (0.00)</td>
<td>0.94** (0.01)</td>
</tr>
<tr>
<td>Sex</td>
<td>0.91 (0.76)</td>
<td>0.89 (0.08)</td>
<td>0.81* (0.07)</td>
</tr>
<tr>
<td>White</td>
<td>Reference group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>0.91 (0.11)</td>
<td>0.90 (0.11)</td>
<td>0.97 (0.13)</td>
</tr>
<tr>
<td>Asian</td>
<td>1.14 (0.11)</td>
<td>1.16 (0.11)</td>
<td>1.37** (0.15)</td>
</tr>
<tr>
<td>Black</td>
<td>0.98 (0.14)</td>
<td>1.054 (0.16)</td>
<td>1.16 (0.21)</td>
</tr>
<tr>
<td>Father’s Education</td>
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<td></td>
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</tr>
<tr>
<td>Less than high school</td>
<td>Reference group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school</td>
<td>1.07</td>
<td>1.16</td>
<td></td>
</tr>
<tr>
<td>Some college</td>
<td>1.21 (0.14)</td>
<td>1.24 (0.16)</td>
<td></td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>1.15 (0.17)</td>
<td>1.25 (0.18)</td>
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</tr>
<tr>
<td>Master’s</td>
<td>0.96 (0.16)</td>
<td>0.93 (0.17)</td>
<td></td>
</tr>
<tr>
<td>Professional</td>
<td>1.56** (0.26)</td>
<td>1.51* (0.26)</td>
<td></td>
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<tr>
<td>PhD</td>
<td>1.21 (0.21)</td>
<td>1.10 (0.21)</td>
<td></td>
</tr>
<tr>
<td>Language</td>
<td></td>
<td>1.22+ (0.12)</td>
<td></td>
</tr>
<tr>
<td>Year Arrived</td>
<td></td>
<td>0.97** (0.01)</td>
<td></td>
</tr>
<tr>
<td>Length of stay</td>
<td></td>
<td>0.99 (0.01)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.88 (0.17)</td>
<td>0.76 (0.17)</td>
<td>15.09** (12.90)</td>
</tr>
<tr>
<td>Observations</td>
<td>3,558</td>
<td>3,489</td>
<td>3,040</td>
</tr>
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Standard errors of the coefficients are in the parentheses. + p≤.1, * p≤.05, ** p≤.01, two-tailed tests.

Table 7 Odds ratios of entering a professional field explained by assimilation indicators and demographic characteristics for U.S. college-educated immigrants.
The logistic regression results partially support hypothesis 4 that predicts that the more assimilated UE immigrants are, the more likely for them to enter professional fields. On the one hand, language proficiency, though measured roughly, significantly improves immigrants’ chance of entering contextual specific fields. Arriving at an earlier age is also beneficial to immigrants’ assimilation into these fields. Both results support hypothesis 4. On the other hand, length of stay does not impact UE immigrants’ chance of entering professional field. Moreover, Asians immigrants are more likely than White immigrants to enter professional fields, while Asians are generally less likely than White immigrants to excel in English. This suggests that language’s effect on field of study is more complicated than assumed by hypothesis 4, and calls for future research. Asians are also believed to hold the strongest science universalism belief, thus the result that they are more likely to switch to professional schools refutes this idea. The Asian exception might be resulted from the higher socioeconomic status of the Asian immigrants relative to some of the White immigrants.

The assimilation factors may affect the probability of entering law, medicine and business differently. Separate investigations of UE immigrants’ probability of entering law, medicine or business at graduate level further reveal the dynamic behind the evolution of their educational pathways. Racial and ethnic differences are only significant for entering business: Hispanic and Asian immigrants are more likely than White immigrants to enter business at the graduate level. Father’s professional degree greatly increases immigrants’ chance of entering law and medicine, but is again not significant in
business. On the other hand, UE immigrant children whose fathers who attained some
college, B.A. degree or Master’s degree are more likely to attain a business graduate
degree, compared with those whose father has less than high school education. Father’s
PhD degree is not a significant predictor in any of the three fields. English proficiency is
a significant predictor of entering business, but not of entering law or medicine. This
suggests that credentialing is more important in law and medicine than in business. Later
year of arrival decreases the probability of entering law and medicine, but not so much in
entering business. Finally, UE immigrants’ longer length of stay decreases their chance of
entering medicine, but no significant difference has been seen in law and business.
Results from table 8 indicate that assimilation factors play a part in the entrance of all
three professional fields, but entering law and medicine seems to require higher family
SES, while entering business seems to require better language proficiency.
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Probability of entering</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Law</td>
<td>Medicine</td>
<td>Business</td>
</tr>
<tr>
<td>Age</td>
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<td>0.75**</td>
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<td>(0.02)</td>
<td>(0.03)</td>
<td>(0.01)</td>
</tr>
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<td>0.45**</td>
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<td>(0.22)</td>
<td>(0.11)</td>
<td>(0.06)</td>
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<td>1.82**</td>
</tr>
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<td>(0.30)</td>
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<td>(0.34)</td>
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<td>Asian</td>
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<td>1.12</td>
<td>1.49**</td>
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</tr>
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<td>Black</td>
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<td>1.10</td>
<td>0.89</td>
</tr>
<tr>
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<td>(0.55)</td>
<td>(0.35)</td>
<td>(0.23)</td>
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<tr>
<td>Father’s education</td>
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<td>Less than high school</td>
<td>** Reference group</td>
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<td></td>
</tr>
<tr>
<td>High school</td>
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<tr>
<td></td>
<td>(0.48)</td>
<td>(0.35)</td>
<td>(0.26)</td>
</tr>
<tr>
<td>Some College</td>
<td>0.96</td>
<td>1.33</td>
<td>1.59*</td>
</tr>
<tr>
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<td>(0.36)</td>
<td>(0.32)</td>
<td>(0.33)</td>
</tr>
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<td>1.40+</td>
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<td>(0.27)</td>
<td>(0.28)</td>
</tr>
<tr>
<td>Master’s</td>
<td>1.64</td>
<td>0.89</td>
<td>1.53+</td>
</tr>
<tr>
<td></td>
<td>(0.62)</td>
<td>(0.25)</td>
<td>(0.36)</td>
</tr>
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<td>Professional</td>
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<td>3.03**</td>
<td>0.89</td>
</tr>
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<td>(0.86)</td>
<td>(0.70)</td>
<td>(0.26)</td>
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<td>PhD</td>
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<td>0.95</td>
<td>1.00</td>
</tr>
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<td>(0.44)</td>
<td>(0.27)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>Language</td>
<td>0.96</td>
<td>0.82</td>
<td>1.83**</td>
</tr>
<tr>
<td></td>
<td>(0.23)</td>
<td>(0.13)</td>
<td>(0.25)</td>
</tr>
<tr>
<td>Year Arrived</td>
<td>0.91**</td>
<td>0.77**</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Length of stay</td>
<td>1.00</td>
<td>0.81**</td>
<td>1.02</td>
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<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Constant</td>
<td>76.19+</td>
<td>6.062e+08**</td>
<td>0.06**</td>
</tr>
<tr>
<td></td>
<td>(170.93)</td>
<td>(1.81e+09)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Observations</td>
<td>3,040</td>
<td>3,040</td>
<td>3,040</td>
</tr>
</tbody>
</table>

Standard errors of the coefficients are in the parentheses. 
+ p ≤ 1, * p ≤ 0.05, ** p ≤ 0.01, two-tailed tests.

Table 8 Odds ratios of entering law, medicine, or business explained by assimilation indicators and demographic characteristics for U.S. college educated immigrants.
Discussion

Horizontal stratification plays a pivot role in shaping the educational pathways of natives and immigrants. Although immigrants are gaining increasing access to U.S. higher education, their progress outside the STEM fields has been uneven. The probability of foreign educated immigrants entering a prestigious non-STEM graduate or professional degree is markedly lower than that for natives or U.S. educated immigrants. In some cases foreign educated immigrants even have to give up their initial degrees in a non-STEM field obtained in their home country and switch to a STEM field, because they lack the contextual knowledge, credentials, and language skills required in such fields. These findings challenge popular beliefs that immigrants’ rapid growth in STEM is solely an advantage they have over natives. Their rapid growth in STEM fields may also be due in part to their lack of access to other emerging opportunities in the prestigious professional fields. In fact, the slower rate of increase in earnings of the STEM fields compared to the professional fields becomes a disadvantage for the immigrants who concentrated in STEM.

Conventional narratives explain little of the difference in the educational pathways of highly educated natives and immigrants. The science pipeline model “is a developmental framework in which the successful completion of all stages within an ideal time schedule means a positive outcome. Non-participation at any stage is equated
with dropping out of the pipeline, and movement back into the pipeline after dropout is assumed to be structurally improbable or impossible” (Xie and Shauman 2003: 8-9). This study of late entry into a field, or switching field of study at later stage of educational pathway, expands the scope of the pipeline model. It shows that dropping out of the science pipeline might not necessarily result in a negative outcome, if students are able to pursue a prestigious non-STEM field. Furthermore, it also shows that movement back into the STEM pipeline is possible, and is more likely to happen among foreign educated immigrants.

This study accounts for field of study and place of education at all stages of tertiary education, and applies log-linear models to depict field switching patterns among natives, U.S. educated immigrants and foreign educated immigrants. It adds new evidence to previous research on immigrant human capital attainment through an examination of the effects of nativity, place of education and gender on people’s educational pathways. Furthermore, the findings speak to immigrant assimilation theory by proving that earlier age at immigration and better command of English enables U.S. educated immigrants to enter contextually specific fields as the natives do. Additionally, the findings do not support gender essentialism hypothesis (Charles and Bradley 2002; Charles and Bradley 2009) that suggests a more segregated gender distribution in field of study for developed societies than developing societies, because the B.A. field distribution and the STEM retention pattern are not significantly different among native females, UE female immigrants and FE female immigrants. However, regardless of place
of education and nativity, females are in general less likely to retain in STEM fields than males.

The analysis in this study aims at describing a pattern of field switching among natives, UE immigrants and FE immigrants, rather than substantiating the causal relationships between this pattern and the possible explanations proposed earlier in the paper, such as level of human capital transferability and science universalism beliefs. Nevertheless, alternative causal relationships exist in addition to the proposed ones, and should be mentioned here. One of them is the independent effect of U.S. immigration policies toward immigrant sending countries. The government can grant more VISAs to foreign scientists, even if graduate schools do not intend to recruit more immigrants. The other alternative, which is also a factor not available from the NSCG dataset, is the ability prior to college entrance. It is well known that immigrants from some source countries have an affinity for STEM fields and have received more intense STEM training in their compulsory education. They thus possess better knowledge and skills than native students. If the intensity of schooling and the prior ability of immigrants can be measured with better datasets, our knowledge on immigrants’ rapid growth in STEM will be enriched.

Future research in the following directions will be fruitful. First, directly examining the market outcomes (e.g., income, earnings) of people who switched out of STEM into professional and people who retained in STEM can reflect the substantial implications of switching field of study. Such study can reveal whether switching from STEM to a professional field can readily be regarded as “switching up”. Second, with
data for larger sample sizes of college students graduated in multiple decades, researchers can further look at the period and cohort change of the comparative advantages of professional fields over STEM fields, or vice versa. Third, distinguishing immigrants from different countries and looking at the patterns that each country’s immigrants exhibit could help reveal why some immigrant groups are especially concentrated in STEM fields. Fourth, if the immigrant sending countries have undergone rapid modernization and achieved a similar level of economic development as in the U.S., will that change the science universalism that their immigrants hold? And will the change of science universalism further change the field of study they choose in the U.S. for further study? Finally, the high expense of professional schools usually means students have to rely on loans. With student loan and debt information, researchers will be able to study whether the financial aid is less available to immigrants, resulting in their lower probability of pursuing a professional degree than natives.

In sum, the analyses in this paper suggest that native-immigrant differences in field switching pattern is a promising avenue for further research. As the structural advantages are moving from STEM fields to professional fields, the rapid growth in the number of foreign educated immigrants and their in-movement to STEM fields can be more of an obstacle than of a vehicle to social mobility.
References


Appendix A: Average Annual Earnings by Advanced Degree Field, Estimates of Full Time Workers from SIPP.

Data: Survey of Income and Program Participation, panel 2001, 2004, 2008. The average monthly earnings in the original SIPP reports were multiplied by 12 to get the annual earnings in this figure.
Appendix B: Field of Study Categorization
Engineering
Aerospace, aeronautical and astronautical engineering
Chemical engineering
Architectural engineering
Civil engineering
Computer and systems engineering
Electrical, electronics and communications engineering
Industrial and manufacturing engineering
Mechanical engineering
Agricultural engineering
Bioengineering and biomedical engineering
Engineering sciences, mechanics and physics
Environmental engineering
Engineering, general
Geophysical and geological engineering
Materials engineering, including ceramics and textile
Metallurgical engineering
Mining and minerals engineering
Naval architecture and marine engineering
Nuclear engineering
Petroleum engineering
OTHER engineering
Electrical and electronic technologies
Industrial production technologies
Mechanical engineering-related technologies
OTHER engineering-related technologies
Architecture/Environmental Design

Biology, life sciences and agricultural sciences
Biochemistry and biophysics
Biology, general
Botany
Cell and molecular biology
Ecology
Genetics, animal and plant
Microbiological sciences and immunology
Nutritional sciences
Pharmacology, human and animal
Physiology and pathology, human and animal
Zoology, general
OTHER biological sciences
Animal sciences
Food sciences and technology
Plant sciences
OTHER agricultural sciences
Math and computer sciences
- Computer and information sciences
- Computer science
- Computer systems analysis
- Information services and systems
- OTHER computer and information sciences
- Computer programming
- Data processing
- Applied mathematics
- Mathematics, general
- Operations research
- Statistics
- OTHER mathematics

Physics and Chemistry
- Chemistry, except biochemistry
- Atmospheric sciences and meteorology
- Earth sciences
- Geology
- Geological sciences, other
- Oceanography
- Astronomy and astrophysics
- Physics
- OTHER physical sciences
- Environmental science or studies
- Forestry sciences
- OTHER natural resources and conservation

Social Sciences
- Economics
- Public policy studies
- International relations
- Political science and government
- Educational psychology
- Clinical psychology
- Counseling psychology
- Experimental psychology
- General psychology
- Industrial/Organizational psychology
- Social psychology
- OTHER psychology
- Anthropology and archaeology
- Criminology
- Sociology
- Area and Ethnic Studies
- Philosophy of science
- Geography
- History of science
- OTHER social sciences
- Social Work
- History, other
- Public administration
- OTHER public affairs
- Home Economics

Law
- Law/Prelaw/Legal Studies

Medicine
Medical preparatory programs
Medicine [dentistry, optometry, osteopathic, podiatry, etc.]

**Business**
- Actuarial science
- Accounting
- Business administration and management
- Business, general
- Business and managerial economics
- Financial management
- OTHER business management/administrative services
- Business marketing/marketing management
- Marketing research

**All others**
- Audiology and speech pathology
- Health services administration
- Health/medical assistants
- Health/medical technologies
- Nursing
- Pharmacy
- Physical therapy and other rehabilitation/therapeutic...
- Public health
- OTHER health/medical sciences
- Agricultural economics
- OTHER agricultural business and production
- Science, unclassified
- OTHER philosophy, religion, theology
- Education administration
- Counselor education and guidance services
- Elementary teacher education
- Physical education and coaching
- Pre-school/kindergarten/early childhood teacher educator, etc
- Secondary teacher education
- Special education
- OTHER education
- Computer teacher education
- Mathematics teacher education
- Science teacher education
- Social science teacher education
- Linguistics
- English Language, literature and letters
- OTHER foreign languages and literature
- Liberal Arts/General Studies
- Dramatic arts
- Fine arts, all fields
- Music, all fields
- OTHER visual and performing arts
- Communications, general
- Journalism
- OTHER communications
- Library Science
- Parks, Recreation, Leisure, and Fitness Studies