Chapter 11

Skilled immigrants' contribution to innovation and entrepreneurship in the United States

by

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Summary

Skilled immigrants to the United States, defined as those with a college degree, outperform college-educated natives in terms of wages, patenting, commercialising or licensing patents, and publishing. This success is due to immigrants who originally entered the United States on a student/trainee visa or a temporary work visa, and is explained by their different fields of study and higher level of education. Skilled immigrants are also more likely to start successful companies than their native counterparts, apparently owing to higher unmeasured entrepreneurial ability. The effect of skilled immigration on per-capita patenting, publishing and starting companies could be larger than implied by immigrants' individual success, if immigrants have positive spill-overs on natives, or could be smaller, if immigration discourages native endeavours. For patenting, there is evidence that immigrants have positive spill-overs.

Skilled immigration has the potential to increase a country's capacity for innovation, thereby boosting productivity growth and ultimately economic growth. To the extent that innovation has a public good component, skilled immigrants might increase the receiving country's per capita welfare simply by increasing the size of the population likely to innovate or have skills complementary to innovation, such as entrepreneurship. However, immigrants might outperform natives if a combination of self-selection and the visa system leads immigrants to be inherently more innovative or entrepreneurial. Alternatively, immigrants may have similar (or lesser) inherent abilities, but be more concentrated in the highest education groups, or more specialised in relevant fields of study and occupations. In either case, immigrants' contribution to innovation could go beyond their own innovation and entrepreneurship, if their presence increases the performance of native collaborators, or if their innovations are inputs to the innovation process of natives who are not collaborators.

While it may appear obvious that a country's total factor productivity benefits from the presence of creative, inventive and entrepreneurial immigrants, certain conditions must hold for this to be true. It must be the case that immigrants would have been less innovative abroad, or would not have been able to commercialise their innovation as

effectively abroad, or that innovation and its dissemination and commercialisation abroad benefit natives less than when these occur at home. These conditions seem likely to hold for the United States.[1] It must also be the case that immigration does not significantly discourage native endeavors in innovation or entrepreneurship, or that any discouragement is mitigated by the productivity gain from workers' greater exploitation of their comparative advantage. There is only partial evidence on this question.[2]

In research co-authored in part with Marjolaine Gauthier-Loiselle, the link between skilled immigration to the United States and innovation and entrepreneurship was examined.[3] The indicators of innovation and entrepreneurship considered are patenting, commercialising and licensing patents, publishing books and papers and writing papers for presentation at major conferences, and starting successful companies. Patents are used to proxy for inventions, which have the potential to increase total factor productivity. While in the short run the purpose of a patent is to keep the benefit of an invention private, once the patent expires or is licensed, the invention may be used by other firms to increase their productivity.

Patenting may also be correlated with innovations embodied in tacit knowledge and disseminated by inter-firm worker mobility. The publication and presentation of books and papers are used to measure dissemination of potentially innovative knowledge created both academically and commercially. Since innovation must be commercialised in order to increase total factor productivity, evidence of the commercialisation of innovation is sought in the commercialisation and licensing of patents, and in the founding of successful companies.

Individual-level data from the 2003 National Survey of College Graduates is used to establish that skilled immigrants outperform skilled natives on all of these measures, and to investigate why this is so, and on what visas the successful immigrants initially entered the United States. For patents, a step further is undertaken with a state-level analysis, using data compiled from the decennial censuses of 1940-2000 and data from the US Patent and Trademark Office, to estimate the causal effects of skilled immigration on patenting per capita, inclusive of any positive or negative spill-overs of immigrants.

The success of immigrants is found to be due to those who originally entered the United States on a student/trainee visa or a temporary work visa, and is explained (except for the case of starting companies) by their different fields of study and higher level of education. The immigrant advantage in starting successful companies is not explained by differences in measured characteristics, and may be caused by greater unmeasured entrepreneurial ability on the part of immigrants. The estimates of the causal impact of skilled immigration on patenting per capita are consistent with positive spill-overs of immigrants on natives, and suggest that immigration was responsible for one third of the large rise in patenting per capita in the 1990s. Together, the evidence suggests skilled immigration to the United States is likely to have raised total factor productivity considerably.[4]

11.1. Data

The individual-level analysis is based on the 2003 wave of the National Survey of College Graduates (NSCG). The survey is a stratified random sample of respondents to the 2000 census long form who reported having a bachelor's degree or higher. All respondents who have ever worked are asked a series of questions concerning the five-year window since October 1998: how many distinct papers they had (co-)authored for

presentation at regional, national or international conferences; how many papers they had (co-)authored had been accepted for publication in refereed professional journals; how many books or monographs they had (co-)authored had been accepted for publication; how many US patent applications they had made; how many US patents had been granted; how many granted patents had resulted in commercialised products or processes or had been licensed.

Questions asked of all respondents currently working allow to construct a dummy variable for whether the respondent had in the last five years founded a company that currently has more than ten employees. It would be preferable to capture companies with at least one employee, but smallest category in the firm size variable is ten or fewer employees. Hourly wages are constructed from salary, weeks and hours on the principal job.

Immigrants (defined by birthplace) are also asked about the type of visa they held when they first went to the United States for six months or more. Information on whether each educational degree was received in the United States allows me to sub-divide the student/trainee visa category according to the stage of their studies at which immigrants arrived.

The sample used to study publishing and patenting contains all those (under age 65) who have ever worked, while the samples for wages and start-ups are of respondents (under age 65) currently working.

The patent data used in the state-level analysis come from the US Patent and Trademark Office (USPTO). Patents are attributed to states based on the home address of the first inventor on the patent. Patents are classified according to application (filing) date. The information on the shares of skilled immigrants and natives in each state, as well as other characteristics of states, come from the IPUMS microdata of the decennial censuses (Ruggles *et al.*, 2010). Alaska and Hawaii are dropped from the analysis, leaving a panel of 48 states over ten yearly intervals from 1940-2000.

11.2. Immigrant performance relative to native performance[5]

Characteristics of immigrants and natives

Table 11.1 shows how the publication and patenting sample is distributed by nativity and entry visa (the other samples are similar). Respondents born abroad outside US territories and without US citizenship (my definition of immigrant) are 12% of the weighted sample. Column 2 shows that 43% of immigrants still in the United States originally entered on a "green card", or permanent resident visa, while 12% originally entered on a temporary work visa. 24% entered on a temporary student or trainee visa, of whom 7.2% entered for college (bachelor's) study, 9.6% for graduate school (master's or doctoral) study, and 2.1% after completing a doctoral or professional degree abroad (post-doctoral research fellows and medical residents or fellows). The residual student/trainee ("other") group, 5.5% of immigrants, entered for high school study or as trainees in firms. 11.6% of immigrants originally entered the United States as dependents of a temporary visa holder, while another 9.0% entered on an unspecified other type of temporary visa.

Table 11.1. Shares of natives and immigrants by entry visa

Percentage

	(1) Full sample	(2) Immigrants
U.S. native	86.4	--
Born American abroad	1.1	--
Born in U.S. territories	0.3	--
Green card	5.2	43.1
Work, temporary	1.5	12
Study/training, temporary		
- for college	0.9	7.2
- for graduate school	1.2	9.6
- for post-doc	0.3	2.1
- for other	0.7	5.5
Dependent, temporary	1.4	11.6
Other temporary	1.1	9
Total	**100**	**100**

Note: Shares weighted with survey weights. Sample of people who have ever worked. 90 293 observations.

Section A of Table 11.2 shows that immigrants are much more likely than natives to have studied computer science/mathematics (an aggregate field dominated by computer science), physical science and especially engineering for their highest degree. Clearly, this is likely to increase immigrant patenting performance relative to natives. Section B, which divides immigrants by entry visa, shows that the overrepresentation of immigrants in computer science and engineering is particularly strong for immigrants who arrived for graduate school and on work visas, while the overrepresentation in physical science is particularly strong for those who arrived for graduate school and as post-doctoral fellows. However, most post-doctoral fellows are in biological science and medicine ("S&E related").

Table 11.2. Weighted distribution of field of study of highest degree by entry visa

Percentage

	A. Immigrant vs native		B. Entry visa type				Study/training			
	U.S. native	Immigrant	Green card	Work	Dependent	Other temporary	for college	for grad school	for post-doc	for other
CS, Math	3.6	8.5	5.5	13.8	9	6.8	9.8	16.8	3.7	6.9
Biological science	4	5.5	4.3	3.2	6.6	4.9	4.7	9.7	24.2	6.5
Physical science	1.7	3.7	3.2	3.7	2.7	3.3	2.2	6.8	11.6	4.9
Social science	10.8	9.1	9.4	7	13	10	7.3	6.2	1.3	11.8
Engineering	5.3	14.4	11.8	21.9	8.3	12.2	18.8	25.1	3.6	14.2
S&E related	12.2	16.8	18.1	18.8	14.7	16.2	12	8.7	50.4	15.8
Non S&E	62.4	41.9	47.7	31.7	45.7	46.5	45.1	26.8	5.1	39.8
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Note: Means of patenting and publishing sample, 90,293 observations, weighted with survey weights. The rows sum to 100. "S&E" means science and engineering. S&E related is principally health. Means for Americans born abroad and individuals born in US territories are not reported.

Rows 1-4 of Table 11.3 show that immigrants are considerably more educated than natives, which will tend to raise their earnings and publishing rates. Section A shows that immigrants have more of every type of post-college degree than natives, with the gap especially large for doctoral degrees, the degree most relevant for publishing. Section B shows that immigrants in every visa group except those who arrived on a green card and on "other" student/trainee visas have more education than natives, including those who arrived for college.

Table 11.3. Weighted means of other individual characteristics by entry visa

Percentage (except ages)

	A. Immigrant vs native		B. Entry visa type				Study/training			
	U.S. native	Immigrant	Green card	Work	Dependent	Other temporary	For college	For grad. school	For post-doc.	For other
Bachelor's	65	56.5	67.1	61.6	60.4	62.8	53.2	0	0	68.5
Master's	26	28.6	22.5	28.6	27.3	25.2	34.6	63.7	0	26.4
Doctorate	2.9	7.7	2.7	6	4.8	3.8	7.7	33.2	51	2.3
Professional	6.2	7.2	7.7	3.8	7.4	8.3	4.6	3.1	49	2.9
Age	44.4	43.3	44.2	42	40.8	44.8	42.9	42.3	46.2	42.6
Age at arrival	--	23.3	21	29.7	18	27.4	21.5	26	29.7	23.4
Highest degree earned in U.S.	99.6	55.5	56.9	17.6	60.4	35.7	97.9	100	0	37.6
Female	50.4	47	51.9	35.2	67	45.6	33.4	32.2	27.9	45.4
White, non-hispanic	88	30.9	30.9	37.7	33.5	31.1	31.9	18.6	39.6	27.4
Currently employed	85.5	86.3	85.1	92.1	81	84.3	87.5	91.1	94.5	85.3
Currently employed at university	4.8	8	4.9	5.4	7.5	5.5	8.1	18.8	38.2	12
Tenure (years)	8.4	6.7	7.4	5.8	5.4	6.5	6.5	5.9	8	7
Self-employed	16.5	17.7	17.2	18	19.7	17.7	20.2	13.9	17.3	20.4

Note: Means of patent and publication sample rows 1-11 and wage sample rows 12 & 13, weighted with survey weights. Means for Americans born abroad and individuals born in US territories are not reported. Master's degrees include MBAs.

Row 5 of Table 11.3 indicates that there are no large differences in current age across the various native and immigrants groups, which explains why age is not an important factor in explaining outcomes across groups in the analysis below. Age at arrival in the destination country is known to be an important predictor of wages for immigrants – wages are higher the younger an immigrant was at arrival. The immigrants youngest on arrival are dependents of temporary visa holders (a mix of children and spouses of the visa holder), while the oldest on arrival are those who arrived on work visas and as post-docs (Row 6), each group with an average age of 29.7. Row 7 shows the share of each entry visa group with a highest degree earned in the United States, which is relevant as a US degree boosts wages.

Rows 8-13 of Table 11.4 give the means of other characteristics by entry visa. Immigrants are slightly less likely to be female than natives (Row 8), especially those who entered on work or study/trainee visas, and all entry visa groups are much less likely to be White and non-Hispanic: only 30.9% of immigrants are White non-Hispanics, compared to 88.0% of natives (Row 9). Immigrants are slightly more likely to be employed than natives, and are considerably more likely to be employed at a university, especially those entering for graduate school or as post-docs (Rows 10 and 11). Immigrants have slightly shorter firm tenure than natives, and are slightly more likely to be self-employed (Rows 12 and 13).

Outcomes of immigrants and natives

Table 11.4 shows the first evidence on the performance of immigrants compared to natives. All differences between immigrants and natives are statistically significant.[6]

Column 1 shows that immigrants earn USD 30.70 per hour compared to USD 29.60 for natives, a narrow immigrant advantage. Column 2 indicates that 0.6% of natives but 0.8% of immigrants have started a company with more than ten workers in the previous five years, a large immigrant advantage.

Table 11.4. Weighted means of outcomes by immigrant status

	(1)	(2)	(3)	(4)	(5)	(6)
	Hourly wage (USD)	Started firm with more than ten workers (%)	Any patent (%)		Publication (%)	
			Granted	Commer-cialised	Any	More than six
U.S. native	29.6	0.6	0.9	0.6	14.4	3.6
Immigrant	30.7	0.8	2	1.3	17.6	6.8
Observations	75 940	78 925	90 293			

Note: Means weighted with survey weights. Publications include published books or journal articles or papers authored for regional, national or international conference presentations. Means for Americans born abroad and individuals born in US territories are not reported.

Column 3 shows that immigrants are more than twice as likely to patent as natives – 2.0% of immigrants have patented in the previous five years, compared to only 0.9% of natives – while Column 4 shows the immigrant advantage is similar for licensing or commercialising patents – 1.3% of immigrants have done so, compared to 0.6% natives. As patents must be licensed or commercialised to contribute to productivity, this outcome is the focus of the subsequent analysis. There is no immigrant/native difference in the number of patents per respondent for respondents who have patented, so this dimension is not explored.

Columns 5 and 6 present statistics on publishing books or articles or authoring papers for regional, national or international conference presentations (which for conciseness are referred to as publishing). 17.6% of immigrants had published (Column 5), compared to 14.4% of natives, a modest immigrant advantage. However, in this case there is an immigrant/native difference in the frequency of this activity. Column 6 indicates that almost twice as many immigrants as natives had published more than six times – 6.8% compared to 3.6% in the subsequent analysis focuses on frequent publishing, assuming that frequent publishers are the key researchers for innovation, though there is no measure of publication quality.

The next regression analyses whether the immigrant advantage over natives still exists when immigrants and natives with similar characteristics are compared. Weighted least squares are used to examine the immigrant/native gap in wages, and probits to examine the gaps in the other, binary, outcomes. The results are reported in Table 11.5. The first column reproduces the raw gaps implicit in Table 11.4: immigrants earn 2.9% more than natives, have a propensity to commercialise patents that is 0.7 percentage points higher than the native propensity of 0.6%, have a propensity to publish more than six papers that is 3.1 percentage points higher than the native propensity of 3.6%, and have a propensity to start successful companies that is 0.18 percentage points higher than the native propensity of 0.61%.

Table 11.5. Immigrant performance advantage over natives

Percentage or percentage points

	(1)	(2)
	Simple comparison	Comparison of similar immigrants and natives
Wages	2.9**	-8.2**
Any patent licensed or commercialised (native propensity = 0.6%)	0.7**	0
More than six publications or papers (native propensity = 3.6%)	3.1**	0.3**
Started firm with more than ten workers (native propensity = 0.61%)	0.18*	0.21**

Note: Coefficients from least squares regressions (log wages) or marginal effects from probits (patents, publications, start-ups), weighted with survey weights. Each coefficient or marginal effect is from a different regression, and in each case the omitted category is US native. Each regression also includes dummies for American born abroad and for those born in US territories. 75 940 observations in for wages, 90 293 observations for patents and publications, 78 925 observations for start-ups. The covariates in Column 2 comprise 29 dummies for field of highest degree (28 for start-ups), dummies for master's, doctorate and professional degrees, dummies for Black non-Hispanic, Hispanic and mixed-race non-Hispanic, a cubic in age, dummies for full-time master's student, full-time doctoral student, and other student. For wages they also include a quadratic in tenure and eight dummies for census region, while for publications they also include a dummy for working and its interaction with employment at a university. ** indicates coefficients significant at the 5% level, * indicates coefficients significant at the 10% level, based on robust standard errors.

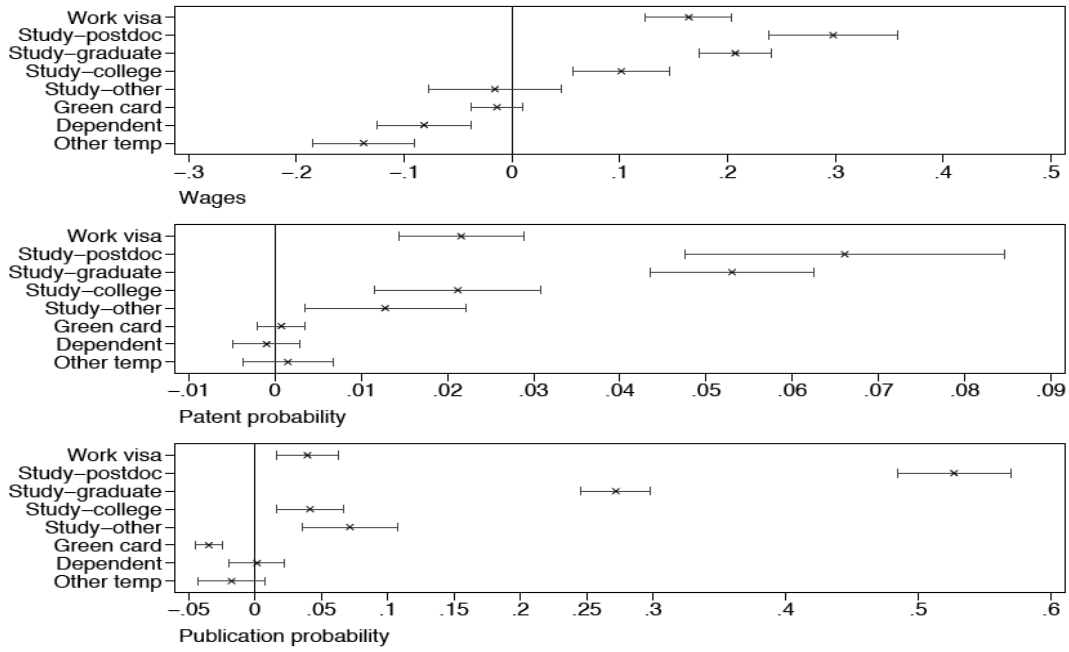
The second column displays the results of comparing immigrants and natives with the same field of study, level of education, age, race and student status.[7] For wages, commercialising patents, and frequent publishing, the adjusted gaps are quite different from the raw gaps. Immigrants earn considerably less, by 8.2%, than similar natives, have the same propensity to commercialise patents as similar natives, and have a scarcely higher propensity to publish more than six papers (the advantage is only one tenth of the advantage in the raw gap in Column 1). The key characteristics explaining the difference between the columns are the field of study of the highest degree and the level of education. Immigrants earn more, commercialise patents and publish more frequently than natives because they have higher education, and fields of study that are more remunerative, more likely to be in science and engineering, and more associated with frequent publishing.

Conversely, the immigrant advantage over natives in start-ups is the same when similar immigrants and natives are compared in Column 2 as in the raw gap of Column 1. Immigrants' heavy concentration among master's and doctoral degree holders is not helpful for founding companies, which tend to be founded by holders of bachelor's or professional degrees, and immigrants are only slightly more concentrated in fields of study associated with starting companies. Their raw advantage is therefore not explained by their superior measured characteristics, but may reflect greater unmeasured entrepreneurial ability.

For policy purposes, it is useful to examine the entry visa types associated with immigrant success in the outcomes considered. This is not possible for firm start-ups, as

there are too few to examine separately by entry visa. However, Figure 11.1 plots the raw immigrant advantage by entry visa for wages (top graph), patent commercialisation (middle graph) and frequent publication (bottom graph). In each graph, the vertical line at zero represents the native baseline, and the x's indicate the relative performance of immigrants in each entry visa. The horizontal lines trace out the 95% confidence interval – statistically speaking, two x's may only be considered reliably different if their 95% confidence intervals do not overlap, and an x is only reliably different from the native value if its 95% confidence interval does not intersect the vertical line at 0.

Figure 11.1. Wages, patent commercialisation and frequent publishing, relative to natives

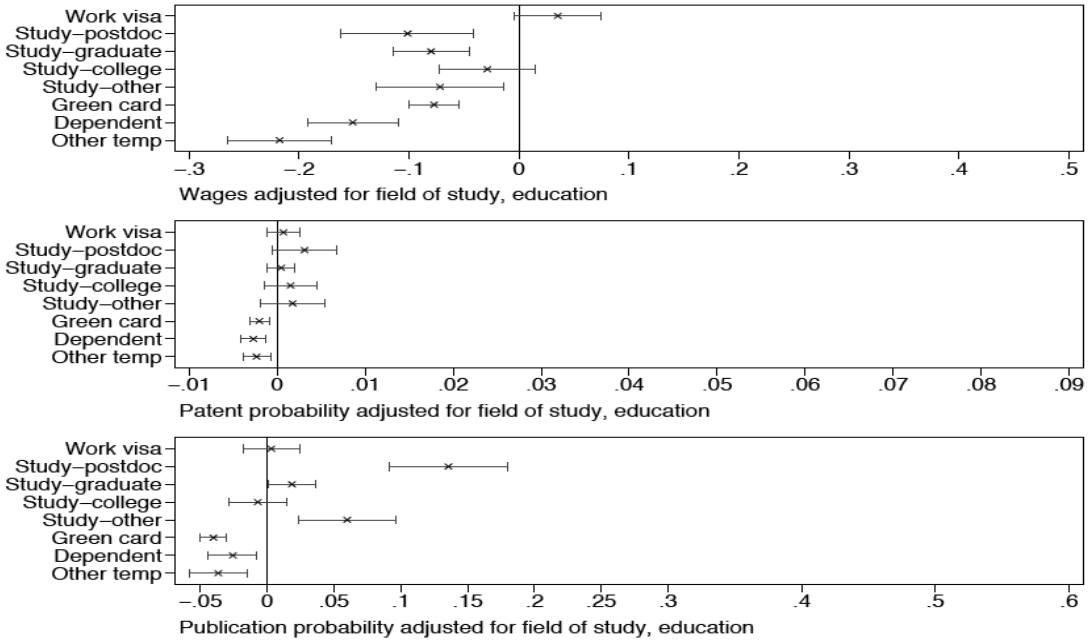


Note: The native patent commercialisation rate is 0.6% or 0.006, the native frequent publication and presentation rate is 3.6% or 0.036. The x's plot the coefficients from weighted least squares regressions (for log wages, 75 940 observations), or marginal effects from weighted probit regressions (for patents and publications, 90 293 observations), and the horizontal lines the (robust) 95% confidence intervals.

All three graphs show that the immigrant wage advantage is driven by immigrants who entered on a work visa or as a student. With one exception ("other" students and wages) all five of these groups statistically significantly outperform natives on all outcomes, while immigrants who entered on green cards, as dependents of a temporary visa holder, or as a holder of an unspecified temporary visa do not outperform natives on any outcome. Immigrants who entered as college students earn 10% more than natives, while those who entered as work visa holders or graduate students earn almost 20% more, and those who entered as post-docs (or medical residents) even more. Immigrants who entered as graduate students or post-docs are more than five percentage points more likely to commercialise a patent than natives. This is an enormous advantage, given that only 0.6% of natives commercialise a patent: it means that more than 5.6% of graduate students and post-docs commercialise a patent. The post-doc advantage in publishing frequently is even more extreme, though less surprising, as it is the job of a post-doc to publish.

In Figure 11.2, the results of regressions used to investigate the reasons for the immigrant success in Figure 11.1 are displayed. In effect, the immigrant performance advantage, by entry visa, when immigrants are compared to natives with the same field of study and level of education is displayed. The top graph shows that no entry visa group has higher wages than similar natives, though the wages of immigrants who entered on a work visa and as college students are similar to those of natives. Similarly, the middle graph shows that each entry visa group has a propensity to commercialise a patent that is at best similar to that of similar natives. The results for the probability of publishing frequently, in the bottom graph, are somewhat different, as post-docs and "other" students retain a large advantage even when compared to similar natives.

Figure 11.2. Wages, patent commercialisation and frequent publishing, relative to similar natives



Note: The native patent commercialisation rate is 0.6% or 0.006, the native frequent publication and presentation rate is 3.6% or 0.036. The x's plot the coefficients from weighted least squares regressions (for log wages, 75 940 observations), or marginal effects from weighted probit regressions (for patents and publications, 90 293 observations), and the horizontal lines the (robust) 95% confidence intervals. Each regression also includes dummies for American born abroad and born in US territories. Field of highest degree is controlled for with 29 dummies, education with dummies for master's, doctorate and professional degrees.

The causal impact of skilled immigrants on patenting per capita

In the previous section, it has been established that immigrants who entered on temporary work visas or as students outperform natives on wages, commercialising patents and frequent publishing, and starting successful companies. The impact of skilled immigration on patenting, publishing and founding companies could be greater or less than the impact implied by the individual success of immigrants, however, due to the possible existence of positive or negative spill-overs. For this reason, Hunt and Marjolaine Gauthier-Loiselle have used the panel of US states to analyse the impact of skilled immigration on patenting per capita and capture the effect net of any positive or negative spill-overs.[8]

Figure 11.3 shows the evolution of total (US origin) US patents and patents per 100 000 residents from 1941-2001, the study period. Patents fluctuate over time, culminating in a large increase from the early 1980s on. The time-series of patents is not thought to reflect the pace of technological change, but rather the financial resources of the USPTO (Griliches, 1990) and changes in incentives to patent (Hall, 2004). Figure 11.4 displays the time-series of skilled immigration to the United States, with a skilled immigrant defined either as college-educated, having post-college education, or being in a science or engineering occupation. All three measures indicate that the share of skilled immigrants in the population (or workforce, in the case of scientists and engineers) has been accelerating since 1960.

The identification of the impact of skilled immigration is not done from national trends, however, but from the relation between changes in immigration and changes in patenting per capita over time within each state after national trends in patenting have been controlled for. We also adopt a technique to account for reverse causality. Any positive association between skilled immigration and patenting could stem not only from a causal impact of immigration on patenting, but from skilled immigrants' being attracted to live in states with growing patenting. Instrumental variables technique is used to isolate the causal effect of interest.[9]

The analysis shows evidence of positive spill-overs of immigrants, since the estimates of their impact on patents per capita are higher than implied by the individual-level NSCG. Column 1 of Table 11.7 shows the results from the simplest specifications. The coefficients come from three weighted least squares regressions, estimated in differenced form, which also hold constant variation across state in skilled native share, average age, Department of Defense procurement spending, land area, 1940 population and 1940 log income per capita. A one percentage point rise in the share of immigrant college graduates in the population increases patents per capita by 13.2 log points or 14%, while the corresponding numbers for immigrants with post-college education are 20.7 log points or 23%, and for immigrants working in science and engineering occupations are 52.4 log points or 69%. In the second column the implied contribution of skilled immigrants to the increase in patenting per capita from 1990-2000 is computed, taking into account the increase in their share of the population or workforce in that period. The implied 1990-2000 increase in the population share of immigrant college graduates from 2.2% to 3.5%, for example, increased patents per capita by 19% in a period when patents per capita rose 63%. Immigrants with post-graduate education and immigrant scientists and engineers arrived in smaller numbers, implying that the impact of skilled immigration on patenting per capita in the 1990s was similar for all three definitions of a skilled immigrant. Column 3 contains the range of values implied by a broader range of specifications than provided in Column 1, including those based on instrumental variables and with a broader set of covariates.

Table 11.6. Impact of a change in skilled immigration on the change in log patents per capita

Change in the share of	(1) WLS regression coefficient	(2) Implied increase in 1990s patenting per capita	(3) Implied increase from preferred coefficients
Immigrants with college degree	13.2**	19%	12-21%
Immigrants with post-college education	20.7*	16%	12-21%
Immigrants working in science and engineering	52.4**	27%	13-32%

Note for Column 1: Each coefficient is from a different regression. The dependent variable is the difference in log patents per capita over ten years, with a lead of one year compared to the independent variables. Estimation is with weighted least squares and weights 1/(1/popt+1+1/popt-9). Regressions also include the changes in the share of skilled natives, the average age, log department of defence procurement spending, land area, 1940 population, 1940 log income per capita and year dummies. Standard errors clustered by state are in parentheses. ** indicates coefficients significant at the 5% level, * indicates coefficients significant at the 10% level.

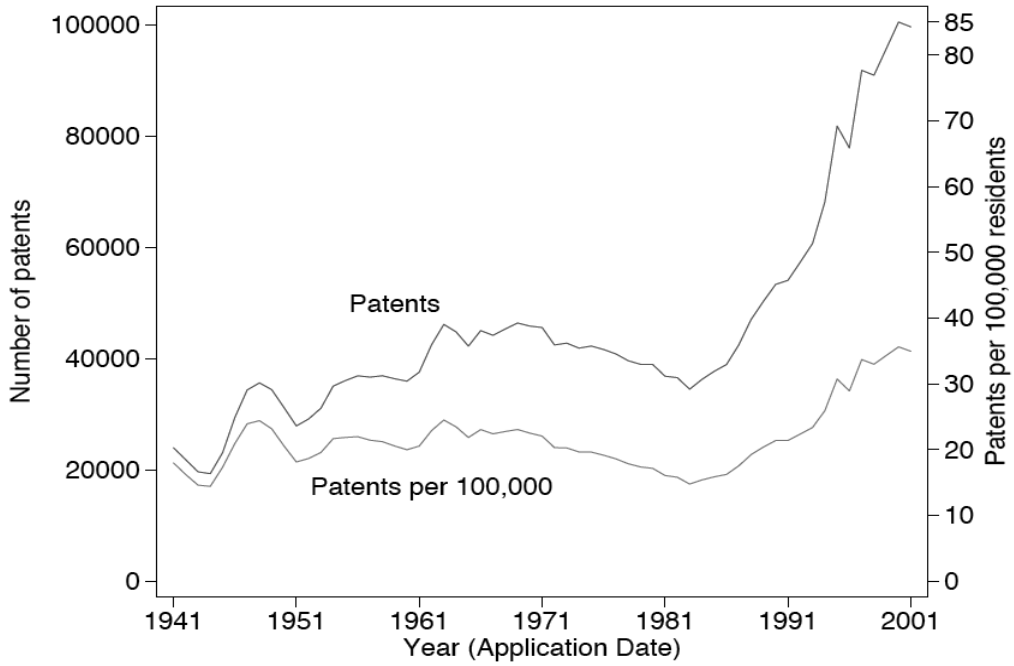
Table 11.7. Means of state-level variables

	(1) 1940-2000	(2) 1940	(3) 2000
Patents/population x 100	0.023	0.018	0.035
	-0.015	-0.013	-0.02
Share of population 18-65 that is:			
Immigrant, college education and above	0.015	0.003	0.035
Native, college education and above	0.127	0.041	0.2
Immigrant, post-college education	0.007	0.001	0.016
Native, post-college education	0.05	0.011	0.077
Share of workers 18-65 that are:			
Immigrant, scientists and engineers	0.003	0.001	0.009
Native, scientists and engineers	0.022	0.006	0.035
Age of population 18-65	38.7	37.7	39.5
	-1	-1	-0.6
DoD prime military procurement contracts	3 236	1 500	5 528
(millions of nominal USD)	-4 386	-1 679	-5 809
State personal income per capita (nominal	11 976	594	29 851
USD)	-11 098	-204	-4 094
Land area (millions of square kilometers)	0.19	0.166	0.207
	-0.161	-0.145	-0.173
Observations	343	49	49

Note: Means of state-level variables for population 18-65, weighted by state population the year after the census. Standard deviations in parentheses. Patents and population are led by one year. Alaska and Hawaii are excluded. Patents are classified by year filed. The predicted increases in immigrant college share (instruments) are based on states' shares of 1940 immigrant high school graduates from various countries and national growth in college graduates from those countries (see text). The 1940 value of DoD procurement spending is not available, and the 1950 value is given instead of 1940, and the 1950-2000 average instead of 1940-2000.

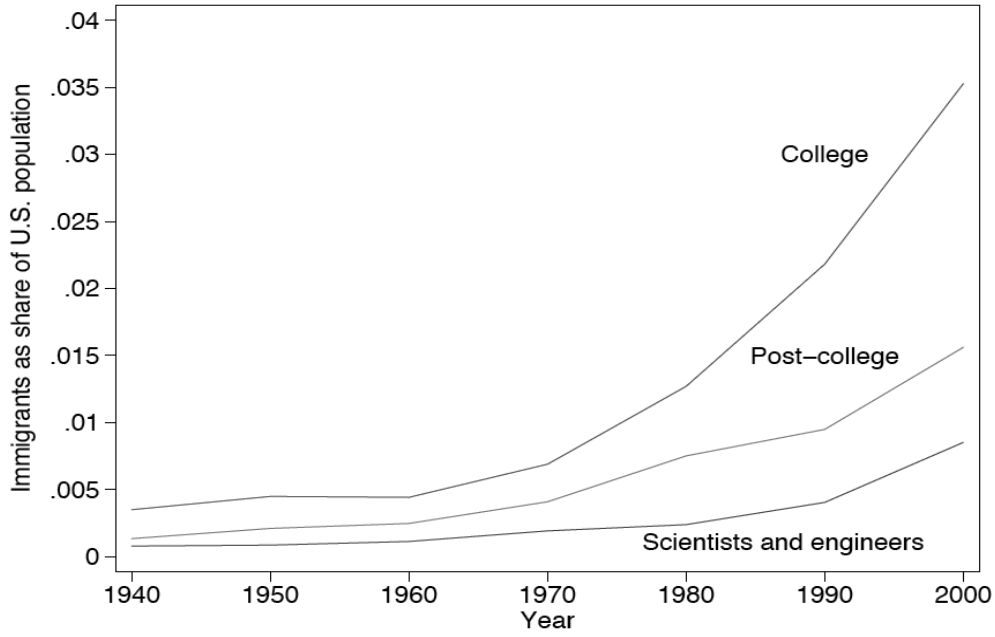
Source: Education, age, occupation, nativity: US Census Bureau, IPUMS decennial census microdata *usa.ipums.org/usa/;* Patents: US Patent and Trademark Office, electronic and paper data; state income, population: Bureau of Economic Analysis *www.bea.gov/regional/spi/*; Land Area: US Census Bureau *www.census.gov/population/censusdata/90den_stco.txt.*

Figure 11.3. US origin US patents, 1941-2001



Source: USPTO, BEA and authors' calculations.

Figure 11.4. Skilled immigrants as a share of US population, 1940-2000



Note: Shares based on population 18-65 for college and post-college and workforce 18-65 for scientists and engineers.

Source: US Census.

11.3. Conclusion

College-educated immigrants to the United States outperform college-educated natives in activities likely to increase US total factor productivity: patenting, licensing and commercialising patents, publishing or presenting books or papers, and starting successful companies. They also have higher wages than their native counterparts. The success of these immigrants is due to those who initially entered the United States on a temporary student or work visa – those who entered on a green card or other visa do not outperform natives on any outcome. The reason that immigrants who entered on a student or work visa are so successful is that they are more educated than natives, and are disproportionately likely to have a highest degree in a science and engineering field, a field in which a lot of publishing takes place or in a well-remunerated field. Only the immigrant advantage in starting successful companies is not explained by these factors. College-educated immigrants seem to have higher unmeasured entrepreneurial ability than college-educated natives, due to a combination of self-selection and the visa system.

These results based on individual-level data suggest that skilled immigrants boost US total factor productivity, and thereby per capita GDP growth. However, the impact may be higher than implied by individual immigrant success, if immigrants enhance the productivity of natives, or lower, if immigrants discourage native endeavours in productivity-enhancing activities. Analysis of a panel of states provides the causal impact of skilled immigration on patenting per capita, inclusive of any spill-over effects. The results suggest there are positive spill-overs of immigrants on natives, and indicate that immigration of college graduates was responsible for one third of the large rise in patenting per capita in the 1990s. Furman, Porter and Stern (2002) find that the elasticity of a country's GDP with respect to its patent stock is 0.113, controlling for capital and labour. This elasticity implies that the influx of immigrant college graduates in the 1990s increased US GDP per capita by 1.4-2.4%.

Notes

1. Kahn and MacGarvie (2008) provide evidence for the first condition, Eaton and Kortum (1999) for the third, while popular wisdom supports the second.

2. Peri and Sparber (2008) show that skilled natives react to skilled immigration by entering occupations with more communicative and interactive skill requirements, in line with their comparative advantage. Borjas (2006) does not find that immigration deters natives as a whole from attending graduate school. Jackson (2009) examines the effect of the skill mix of immigration, but not the level of immigration, on native college attendance. Fairlie and Meyer (2003) find that immigration reduces native self-employment rates, but do not study skilled immigration specifically.

3. Hunt (2009), Hunt and Gauthier-Loiselle (2010).

4. Relevant existing papers on immigration and patenting include Chellaraj, Maskus and Mattoo (2008), Kerr (2008), Kerr and Lincoln (2010), Morgan, Kruytbosch and Kannankutty (2001), Peri (2007), and Stuen, Mobarak and Maskus (2010). Papers on initial immigrant visa and

earnings include Lowell and Avato (2007), Massey and Nalone (2002) and Sweetman and Warman (2009).

5. This section summarises results from Hunt (2009) based on the NSCG micro-data.

6. The difference in Column 2 is statistically significant at the 6% level.

7. There are some additional controls for wages and publications – see the table notes.

8. Hunt and Gauthier-Loiselle (2010).

9. The excluded instrument is the predicted increase in skilled immigrant shares, based on states' shares of 1940 immigrants from various countries and subsequent national growth in skilled immigrants from those countries.

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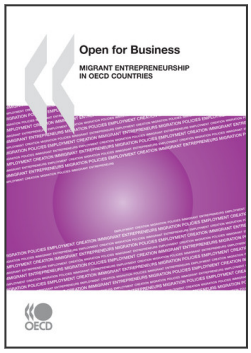

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