Paper to be presented at the

35th DRUID Celebration Conference 2013, Barcelona, Spain, June 17-19

Immigration Law and Mobility of Inventors

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Abstract

Attracting talent is an issue of central concern for small entrepreneurial firms. But prior research has contradictory findings regarding the conditions that make recruitment easier. In particular, findings regarding the opportunity cost of working for a start-up have been contradictory. One line of findings suggest that increases in the range of available alternatives for employees increase their opportunity cost and makes recruitment of talent to younger firms harder. On the other hand, increases in the range of available alternatives also ?cushion? the potential employee in case the young firm fails and might thus make recruitment of talent easier. We focus here on how immigration law influenced the mobility of innovators. Our findings suggest that increasing the range of alternatives by making mo- bility easier leads to a greater flow of talent to smaller and younger firms. Our findings thus support the cushioning hypotheses.

Jelcodes:O32,K31

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Abstract: Attracting talent is an issue of central concern for small entrepreneurial firms. But prior research has contradictory findings regarding the conditions that make recruitment easier. In particular, findings regarding the opportunity cost of working for a start-up have been contradictory. One line of findings suggest that increases in the range of available alternatives for employees increase their opportunity cost and makes recruitment of talent to younger firms harder. On the other hand, increases in the range of available alternatives also "cushion" the potential employee in case the young firm fails and might thus make recruitment of talent easier. We focus here on how immigration law influenced the mobility of innovators. Our findings suggest that increasing the range of alternatives by making mobility easier leads to a greater flow of talent to smaller and younger firms. Our findings thus support the cushioning hypotheses.

1 Introduction

Attracting and retaining talented human capital is critically important but challenging for small entrepreneurial firms, especially in human-capital intensive industries such as high-technology industries. Prior literature suggests this challenge is likely to increase when the labor market opportunities for potential employees increase (Amit et al. 1995; Arora and Nandkumar 2011; Bhide 2000; Shane and Venkataraman 2000). The core proposition is that greater employment prospects increase the potential employees opportunity cost of joining a less stable firm with uncertain returns. Empirical evidence for this proposition is however ambiguous (Cassar 2006). Prior research has tested the proposition by measuring increased labor market opportunities through correlates of individuals human capital such as experience or foregone wages and relating the measures to decisions to open or persist in entrepreneurial ventures (Amit et al. 1995; Arora and Nandkumar 2011). Some studies find these measures associated negatively with entrepreneurship (Amit et al. 1995; Arora and Nandkumar 2011), while others find no relationship (Hamilton 2000) or a U-shaped relationship (Poschke 2012) and yet others find a positive relationship (Kim et al. 2006; Robinson and Sexton 1994).

This ambiguity in findings reflects both theoretical and empirical limitations of extant research. Theoretically, the opportunity cost argument does not take into account the possibility that decision makers view down-side risks differently from upside potential which is pointed out by behavioral scholars (Dew et al. 2009; Jeffrey et al. 2009; March and Shapira 1987). Greater labor market opportunities not only increase the opportunity costs of joining small but risky ventures but also reduce the downside consequences of failure by providing a cushion of options should the risky option fail. This "cushioning" effect may indeed encourage potential employees to join small entrepreneurial ventures. Empirically, most ex-

aminations use an individuals human capital related measures such as experience or foregone wage to measure opportunity cost. But individual level factors that are correlated with an individual's employment prospects are also likely to increase the expected returns of the small venture that she joins thereby influencing her decisions to join the venture (Arora and Nandkumar 2011). Hence it is difficult to isolate the effect of opportunity costs by using individual human-capital correlates.

To resolve these issues, we build on the two above-mentioned alternate perspectives to derive competing hypotheses regarding the impact of increased employment opportunities on the decisions of R&D professionals to work in smaller and less stable firms. Empirically, we isolate the impact of greater employment prospects by exploiting a legal change in the US immigration law that exogenously altered the employment prospects of a section of R&D work force - the H-1B work visa holders - without influencing the quality of human capital and expected returns of risk taking. We use a difference-in-differences methodology to investigate how this change in law impacted the mobility and employment patterns of immigrants compared to non-immigrants. We find that this increase in employment prospects increased the proclivity of immigrant R&D professionals to work in smaller and younger firms which is consistent with the perspective on risk taking found by behavioral scholars.

This study contributes to our understanding of innovation and entrepreneurship in many ways. First it gives us new insights into the challenges faced by young high-technology entrepreneurial firms in attracting human capital. Isolating the impact of increased employment opportunities enables us to distinguish between two different conceptualizations of R&D professional's attitudes toward risk and understand which one of them most likely apply. Furthermore, this study sheds light on the employment related preferences of a significant section of the R&D workforce. Both research and popular press accounts have

documented the importance of immigrants to technological innovation and entrepreneurship. Although they are a significant source of technological talent, our knowledge of their employment preferences is limited because their mobility choices are constrained by a number of immigration laws. This study by examining the relaxation of one of these laws provides us a window of opportunity to examine their choices.

2 H-1B law change and mobility of R&D professionals.

A number of studies demonstrate the importance of immigrant R&D professionals in technological innovation and entrepreneurship in the US economy (Kerr 2008; Kerr and Lincoln 2010). Immigrants constitute a considerable proportion of the scientific and engineering workforce in US high-technology industries. Many prominent startups in the high-technology sector have been founded by immigrants.

The employment of many of these immigrant R&D professionals is governed by the H-1B visa. The H-1B visa is a employer sponsored visa that allows highly skilled immigrants to work for the sponsoring US firms. This program has been a subject of much controversy regarding whether or not this replaces US workers and whether firms exploit this provision by paying less to equally capable foreigners. Among the biggest votaries of this law have been the largest firms in the US high tech sectors such as SUN and Microsoft etc [1].

As the quote below demonstrates, many of the H-1B R&D professionals are not hired from outside of the United States. They are hired from within the US from other firms or from the technical and engineering colleges including prestigious programs like MIT and Stanford.

"...of all the H-1B workers that Sun has hired, only a very small handful are

[1]Senate Report 106-260 on the American Competitiveness in the twenty-first century act in 2000

> actually recruited outside the United States and then brought into the country. The majority of H-1Bs that Sun hires are already in the U.S. having graduated from United States schools frequently at the top of their class." (Kenneth Alvares, VP-HR, Sun Microsystems, Senate committee hearing, 1998 as reported in Senate Report 106-260)

Clearly the H-1B visa program is an important vehicle for firms in high-technology industries to hire talented R&D professionals from the pool of immigrants in the US. The H-1B visa limits the length of stay within US. It allows the immigrant to stay for three years and is then extended to another three, leading to a maximum of six. If the immigrant does not get the H-1B status changed to a more stable status such as permanent residency, he or she needs to stay outside of US for at least one year before applying for another H-1B visa.

Before the October of 2000 this law severely restricted the employment options of H-1B holders. For a H-1B holder to change jobs, the new employer has to file a H-1B transfer petition. Prior to October 2000, a H-1B holder could start working for the new employer only after the USCIS (then called the INS) had approved the petition. This approval process took between 4-6 months and therefore severely restricted the mobility of immigrant high skill workers. With the enactment of American Competitiveness in the Twenty-first century act of 2000 on 17 October 2000 however, the law was changed to allow the H-1B holder to start working for a new employer right after the new employer filed a transfer petition.

This change in law, commonly known as the "H-1B portability provisions"[2], made the process of switching jobs much easier for H-1B holding R&D professionals and thereby increased their employment prospects. Before the change in law, these professionals could start working for new employers only after a period of 4-5 months after the new employer

[2]http://www.visapro.com/S/Article-Print-Preview.asp?articleid=1327

filed a petition. This required the new employer to be able to predict the need for the professionals about six months in advance. This long period most likely also imposed significant costs on the employee who would have to either ensure that her attempt to move to another employer is kept secret in the current firm or else risk reduced career prospects within the firm or even risk losing her job. After the law change however, it became easier for firms to hire H-1B holders as well as for employees to start working in a new firm. As a result, the set of available employment opportunities increased for the H-1B holding employees. This change in law however did not impact the permanent residents and citizens. We therefore predict the following.

Hypothesis 1. The mobility of H-1B holding R&D professionals, compared to non-H-1B holding R&D professionals, increased after the enactment of American Competitiveness in the Twenty-first century act of 2000 on 17 October 2000.

Hypothesis 1 is clearly quite intuitive. We test it to establish the validity of the proposition that the change in H-1B law did increase the employment opportunities available to immigrant R&D professionals. How this increase in opportunities would impact the proclivity of immigrant high-technology professionals to work in small and young firms is not clear. Two competing perspectives on risk bear on the issue.

The traditional opportunity cost based arguments suggest that the proclivity of R&D professionals to work for small firms should be negatively impacted by increased employment prospects. From the perspective of traditional risk-return trade-off, the expected returns of risky choices should be higher. When the barriers to mobility are reduced, it is likely to increase the opportunity cost of joining less stable firms since the number of employment options including those in larger firms with more certain wages increase. Thus the threshold of expected returns beyond which moving to risky ventures is justified, increases. As discussed,

the change in H-1B law reduced the barriers of mobility for immigrant R&D professionals. Hence the law change should have increased the threshold of expected returns beyond which moving to small firms is justified. This change however did not alter the expected returns from small firms. As a result, we should expect the proclivity of R&D professionals to work for small and young entrepreneurial ventures to decrease. This line of logic leads to the following set of hypotheses.

Hypothesis 2a. The immigrant R&D professionals are less likely to work for smaller firms after the enactment of American Competitiveness in the Twenty-first century act of 2000 on 17 October 2000.

Hypothesis 2b. The immigrant R&D professionals are less likely to work for younger firms after the enactment of American Competitiveness in the Twenty-first century act of 2000 on 17 October 2000.

The opportunity cost argument however does not take into account the findings from the literature that examines the behavioral attitudes towards risk taking (Dew et al. 2009; Jeffrey et al. 2009; March and Shapira 1987). This literature demonstrates that decision makers typically view risk as the magnitude of down-side or negative outcomes rather than as a probability distribution of uncertain outcomes that can be both positive or negative. This stream of literature has also found that decision makers are willing to make risky choices as long as they can manage or reduce the bad consequences of those choices. Thus any change that limits the consequences of bad outcomes of a risky choice is likely to make the choice more attractive. Similar conclusion can be drawn from the real options perspective (McGrath 1997, 1999).

From this perspective, it follows that increase in employment options makes working for risky firms with greater potential upside more attractive by limiting the consequences of

firm failure. This is because as employment options increase, the chances of finding a new employer should your current firm fail also increase. This limits the downside of working for a small unstable firm without changing the potential upside. Since H-1B law change increased the employment options for immigrant R&D professionals, one would expect the same dynamic to play out in our context. Before the change in law, the consequences of failure of employing firm could be quite dire for immigrants. Since the immigrants would not be able to start work for another employer for few months, their immigration status would be in jeopardy and they would most likely have to leave the country to remain legal. The change in the law limited this downside and thus could be expected to increase the proclivity of immigrants to work for small if unstable ventures. This logic suggests an alternate set of hypotheses.

Hypothesis 3a. The immigrant R&D professionals are more likely to work for smaller firms after the enactment of American Competitiveness in the Twenty-first century act of 2000 on 17 October 2000.

Hypothesis 3b. The immigrant R&D professionals are more likely to work for younger firms after the enactment of American Competitiveness in the Twenty-first century act of 2000 on 17 October 2000.

3 Data & Methods

Our data comes from the "Disambiguation and Co-authorship Networks of the U.S. Patent Inventor Database (1975 - 2010)" project (Lai et al. 2011) and covers the careers of inventors who filed patent applications in the USA. The project has specifically focused on identifying individual inventors and their employers in the patent data and is thus very suitable for our purpose. Patent data has been used extensively to study the mobility of innovators (e.g.

Marx et al. 2009).

We identify mobility events by looking at two consecutive patents filed by the same inventor and looking at the assignees of those patents. If the patents belong to different companies, we assume that the inventor moved between those to companies at the midpoint of the patent filing dates, in line with prior literature (e.g. Marx et al. 2009). Each observation thus corresponds to a pair of patents and the mobility outcome is coded as zero if the patents have the same assignee and one if they have a different assignee.

We establish the likelihood of an innovator being an H-1B holder by matching his or her name to an ethnicity using an established algorithm (Kerr 2008; Kerr and Lincoln 2010). We assume that innovators with Indian or Chinese names are more likely to be H-1B holders than innovators with Anglo-Saxon names. This is naturally a noisy measure, but has been used in the past (Kerr and Lincoln 2010) and any noisiness in it will bias the regressions against finding a result. That is, the extent to which there are H-1B holders among those with Anglo-Saxon names on one hand and citizens or green card holders among those with Chinese and Indian names will move the estimates towards zero, away from finding a result. This assumption is thus quite conservative.

Since an H-1B visa can only be held for six years (or in rare cases nine years if working for the military), we limit our sample set to innovators whose first patent is at most two years prior to the law change and look at potential mobility events (i.e., the midpoint of pairs of consecutive patents) in a window extending from two years before the law change in 17 October 2000 to two years after it. We also limit the data to inventors whose address during this period was always in the US and who were not self-employed (i.e., did not have patents without assignee as H-1B holders must maintain employment). While there were changes in the quota of H-1B visas given each year, they have no effect on our estimates as

H-1B holders changing employment do not count towards the quota.

We measure the size and age of the employer by looking at the number of patents filed by the employer in the previous five years and the number of years since the first patent[3], respectively. While both of these are noisy measures of actual company size and age, they do give a relatively accurate assessment of the size and age of the company's innovative efforts, which is arguably the right thing to consider.

We identify the impact of the law change by using differences-in-differences regressions and comparing the Anglo-Saxon innovators with the Chinese & Indian innovators before and after the H-1B law change. We add controls for the year, state of residence, and technology class of the patent as well as years since first patent.

Table 1 reports the basic mobility regressions. Each observation is a pair of consecutive patents by the same inventor and the dependent variable is zero if they belong to the same assignee and one if they belong to different assignees. The estimations are logit regressions. The variable "H-1B holder" is a dummy variable indicating that the inventor has a name of Indian or Chinese origin. The control group is inventors with Anglo-Saxon names. The variable "Law change" is a dummy indicating the period after 17 October 2000[4]. As can be seen in the regressions, the law change did have a significant positive effect on the mobility of H-1B holders. The effect is robust to a range of controls and the magnitude is very stable.

Table 2 addresses potential alternative explanations. Model 1 separates Indian and Chinese inventors and finds that they both experienced an increase in mobility. Model 2 uses an alternative inventor identification procedure and finds similar results. Model 3 uses an alternative ethnicity matching procedure and finds similar results. Models 4, 5, and 6 are placebo regressions addressing the potential concern that there is something else about the

[3]This measure is naturally capped by the beginning of the patent data in 1975.

[4]The main effect of the law change is naturally captured by the year dummies.

Chinese and Indians compared the Anglo-Saxons than the higher likelihood of being H-1B that is driving the results. Model 4 creates an artificial law change three years prior to the the actual law change with a new dataset of innovators whose first patent was at most two years prior to the artificial law change date. We find no result. Model 5 repeats the same exercise with an artificial date three years after and also finds no result. Thus, there really was a change in 2000 that affected the Indians and Chinese differently than the Anglo-Saxons. Model 6 then considers that actual law change but looks at inventors whose first patent was at least ten years earlier and who thus cannot have been H-1B holders. Again, there is no result, giving greater confidence to the findings. Model 7 then uses a linear probability model (i.e., ordinary least squares) and finds the same effect as logit, suggesting that the findings are not driven by a peculiarity of the logit regression.

The evidence presented in Tables 1 and 2 is thus consistent with Hypothesis 1.

Table 3 then considers the size and age of inventors' employers. Each observation is again a pair of consecutive patents by the same inventor and the dependent variables are measures of the size and age of the assignee of the latter patent in each pair, i.e., the new employer if there was a change of employment. The estimates are ordinary least squares. Models 1 and 3 show that H-1B holders on the average work for larger firms than others, which is to be expected, but that this difference is diminished after the law change. H-1B holders seem to be moving to smaller and younger firms.

Table 4 address potential alternative explanations, like Table 2 did, though focusing only on the size of the new employer. Model 1 again breaks down the H-1B holders into Indians and Chinese and finds that both experienced a similar change. Models 2 and 3 present alternative inventor and ethnicity matching algorithms, respectively, and find similar results. Models 4 and 5 consider measures of the size of the employer based on the number of patents

in the prior 3 or 7 years, instead of 5. The results are similar. Models 6, 7, and 8 are placebo tests comparable to Models 4, 5, and 6 in Table 2. We find no result at the two artificial law changes or among those who could not have been H-1B holders.

The evidence presented in Tables 3 and 4 is thus consistent with Hypotheses 3a and 3b, not 2a and 2b.

4 Discussion

Given the importance of human capital for entrepreneurial firms, it is important to understand the conditions that facilitate or hinder the recruitment of talent by such firms. In this paper, we have focused on getting a handle on how increasing labor market opportunities for employees affect their likelihood of working for smaller firms. The evidence suggests that greater labor market opportunities serve to cushion the downside risk of working for a smaller firm, namely the risk that the company goes under and one is left without a job, and thus increase the likelihood of working for a smaller firm.

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Table 1: Changing Employers (Logit)

	(1)	(2)	(3)	(4)	(5)
Time from 1st patent					0.608**
					(0.05)
Time from 1st patent, sq					-0.124**
					(0.01)
H-1B holder	0.0337	-0.000291	-0.00637	-0.0105	-0.0140
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
H-1B holder x Law change	0.140**	0.133*	0.139**	0.137**	0.134*
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Year dummies	Y	Y	Y	Y	Y
State dummies	N	Y	Y	Y	Y
Tech category dummies	N	N	Y	N	N
Tech subcategory dummies	N	N	N	Y	Y
Pseudo-R2	0.00449	0.0167	0.0198	0.0227	0.0266
Log-likelihood	-36321.6	-35875.0	-35739.0	-35631.8	-35489.8
Clusters	29016	29015	29006	29006	29006
Observations	75826	75824	75766	75766	75766

Standard errors in parentheses, clustered by inventor. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Table 2: Changing Employers (Logit, robustness checks)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Alternative Inventor Match	Alternative Ethnicity Match	Artificial Law change 1997	Artificial Law change 2003	Inventors with at least 10 years from 1st patent	
Estimation	Logit	Logit	Logit	Logit	Logit	Logit	OLS
Time from 1st patent	0.609**	0.614**	0.549**	0.586**	0.472**	-0.00764	0.0854**
	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.02)	(0.01)
Time from 1st patent, sq	-0.124**	-0.126**	-0.107**	-0.0905**	-0.0873**	-0.0000734	-0.0172**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)
Indian	-0.116+						
	(0.07)						
Chinese	0.0595						
	(0.06)						
Indian x Law change	0.158*						
	(0.08)						
Chinese x Law change	0.117+						
	(0.06)						
H-1B holder		0.0281	-0.0337	0.0438	0.0637	-0.0172	-0.00288
		(0.05)	(0.05)	(0.06)	(0.04)	(0.05)	(0.01)
H-1B holder x Law change		0.0938+	0.170**	0.0484	-0.0645	-0.0911	0.0235**
		(0.05)	(0.05)	(0.06)	(0.05)	(0.07)	(0.01)
Year dummies	Y	Y	Y	Y	Y	Y	Y
State dummies	Y	Y	Y	Y	Y	Y	Y
Tech subcategory dummies	Y	Y	Y	Y	Y	Y	Y
R^2							0.025
Pseudo-R2	0.0268	0.0269	0.0249	0.0324	0.0325	0.0274	
Log-likelihood	-35481.8	-35011.9	-38568.7	-36364.0	-32366.1	-36151.3	
Clusters	29006	28498	31478	25653	26925	20897	29007
Observations	75766	75207	81702	74386	68410	70231	75768

Standard errors in parentheses, clustered by inventor. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Table 3: Size & age of (new) employer (OLS)

	(1)	(2)	(3)	(4)
Dependent variable	Log patents in prev. 5 yrs	Log patents in prev. 5 yrs	Log years from 1st patent	Log years from 1st patent
Sample	All	Movers	All	Movers
Time from 1st patent	-0.00188	0.0569	0.0826**	0.0602
	(0.06)	(0.10)	(0.02)	(0.04)
Time from 1st patent, sq	0.0245+	0.00255	-0.00328	0.00472
	(0.01)	(0.03)	(0.01)	(0.01)
H-1B holder	0.718**	0.586**	0.175**	0.193**
	(0.06)	(0.10)	(0.02)	(0.04)
H-1B holder x Law change	-0.174**	0.0931	-0.0477*	0.0338
	(0.06)	(0.11)	(0.02)	(0.05)
Year dummies	Y	Y	Y	Y
State dummies	Y	Y	Y	Y
Tech subcategory dummies	Y	Y	Y	Y
R^2	0.180	0.092	0.080	0.053
Clusters	29007	9251	29007	9251
Observations	75768	14136	75768	14136

Standard errors in parentheses, clustered by inventor. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Table 4: Size of (new) employer (OLS, robustness checks)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Alternative Inventor Match	Alternative Ethnicity Match	Log patents in previous 3 years	Log patents in previous 7 years	Artificial Law change 1997	Artificial Law change 2003	Inventors with at least 10 years from 1st patent
Time from 1st patent	-0.00249	-0.00563	-0.0408	-0.00772	-0.00924	-0.119*	-0.0265	-0.0390
	(0.06)	(0.06)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)	(0.03)
Time from 1st patent, sq	0.0245+	0.0260+	0.0310*	0.0195	0.0277+	0.0174+	0.0224+	0.00107
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.00)
Indian	0.935**							
	(0.09)							
Chinese	0.545**							
	(0.07)							
Indian x Law change	-0.171+							
	(0.09)							
Chinese x Law change	-0.175*							
	(0.07)							
H-1B holder		0.726**	0.671**	0.707**	0.724**	0.480**	0.543**	0.179*
		(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)
H-1B holder x Law change		-0.180**	-0.129*	-0.202**	-0.166**	-0.0571	0.0357	-0.00360
		(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)	(0.07)
Year dummies	Y	Y	Y	Y	Y	Y	Y	Y
State dummies	Y	Y	Y	Y	Y	Y	Y	Y
Tech subcategory dummies	Y	Y	Y	Y	Y	Y	Y	Y
R^2	0.181	0.181	0.177	0.190	0.179	0.202	0.209	0.225
Clusters	29007	28499	31479	27985	27985	25653	26926	20902
Observations	75768	75209	81703	73017	73017	74386	68412	70249

Standard errors in parentheses, clustered by inventor. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$