Ethnic Inventors: A Critical Survey of the Contribution of People of Middle Eastern Ethnic Backgrounds to the US Innovation System

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Abstract

We study the contribution of inventors with a background from the MENA (Middle East and North Africa) region to the US innovation system. Matching 2,500 MENA specific first names with WIPO patent documents, we provide evidence of the role this community plays in the US innovation system. We find that the share of inventors in total inventive activity with a MENA background has increased considerably in the last 20 years. They concentrate in California and tend to specialize in computers, communication and software, as well as in medical and veterinary sciences. They are also active in technology areas that are core competencies for their employers.

1. Introduction

Innovation and the creation of new technologies has become an internationalized process (Narula and Zanfei 2005; Dachs, Stehrer and Zahradnik 2014). An important form of internationalisation is the employment of highly-skilled migrants, including students, engineers and scientists. Various studies using patent data and data on the background of start-up founders point to the fact that foreign-born workers stand behind - partially or wholly - 25% of all patents filed in the US and all technology companies founded (Wadhwa, et al. 2007; Kerr et al. 2015).

In this paper, we will examine the role of highly skilled immigrants from the Middle East and North Africa (MENA) region, on the US innovation system - in particular their role in patenting activities. MENA is largely the home region to Arabs, Kurds, Persians, and Turkish ethnicities. The paper follows the approach pioneered by William Kerr who investigated immigrant inventions in the US in a series of papers (Kerr 2007; Kerr 2008; Kerr and Lincoln 2010; Kerr 2013). Kerr's research reveals a growing share of inventors with an ethnic background other than English or European in overall US inventive activity. In particular, the contribution of inventors with a Chinese, Indian, Japanese or Korean background increased considerably since the 1970s. Inventors with a Chinese background nearly doubled their share on total patent inventions from 4.6% (1990-1994) to 9.5% (2000-2004 (Kerr and Lincoln, 2010).

In addition to evidence on the increasing importance of migrant inventors, various contributions also revealed qualitative effects of their presence on their employer firms. Foley and Kerr (2013) demonstrate that an increase in the share of innovators with a particular ethnic background is associated with higher assets, higher sales, higher employment and more frequent R&D activities of US multinational in these ethnic regions. Breschi et al. (2015) show co-ethnicity ties bridge spatial distance, and help firms to gain knowledge from other ethnic inventors through the international diaspora effect. Useche et. al. (2016) find that migrant inventors affect their employers' choice of targets of Cross-Border Merger & Acquisitions by favouring those located in their home country. Miguélez (2016) documents the influence of diaspora networks of highly-skilled individuals on international technological collaborations and finds a strong and robust relationship between inventor diasporas and different forms of international co-patenting.

The aim of our paper is to complement this research with a perspective on MENA migrants. So far, the majority of the research on highly skilled diaspora and migrant inventors have focused on the Chinese and Indian ethnicities. Very little if any research has been done on the contribution and impact of highly skilled immigrants from the Middle East and North Africa region. However, the topic gained importance against the background of recent policy discussions on a travel ban for citizens of some of the MENA countries.

The remainder of the paper is structured as follows: the next section 2 provides some statistics on the MENA community in the US, while section 3 describes the data and our approach. Section 4 presents the empirical results. Section 5 concludes.

2. The MENA community in the US

Unlike, Indian citizens who take 65% of Hi-B visa, people from the Middle East and North Africa in general do not benefit much from the H1-B visa receiving collectively less than 10% of total visas granted to foreign-born skilled workers (USCIS, 2013). While there were around 108,000

students from the Middle East and North Africa in the US in 2016, people from this region are not among the top recipients of PhDs at US universities. (NSB, 2012) This could be an indication that the bulk of US MENA skilled immigrants settle in the US through other immigration channels, such as family reunion and as refugees. This has an implication for the immigration debate going on in the US. In 2013, there were approximately 1.02 million immigrants from MENA countries residing in the United States, representing 2.5 percent of the nation's 41.3 million immigrants (Zong and Batalova 2015). This number refers to individuals originating from predominantly Arab countries, and excludes US-born MENA people. Furthermore, the American Community Survey 2011 indicates that there are around 470,000 persons in the US who are Iranian-born. A similar number is estimated for people of Turkish origins in the US (Assaker 2012). About 43 percent of Arab immigrants (ages 25 and over) had a bachelor's degree or higher, compared to 28 percent of all immigrants and 30 percent of native-born adults. Skilled MENA immigrants are more likely than other major ethnic groups to arrive to the US on a non-skilled visa.

The United States hosts a very diverse immigration populace that originate from the MENA region. Roughly 70% of these immigrants come from the Middle East, while the remaining 30% originate from North Africa (as seen in Table 1). Iraq holds the largest share of immigrants moving to the USA with Egypt and Lebanon closely following in numbers (Zong and Batalova 2015).

Table 1 Distribution of MENA Immigrants by Country of Origin, 2013

Country and Region	Number of Immigrants	Percent (%)
Middle East	695,000	68.3
Iraq	201,000	19.8
Jordan	68,000	6.5
Kuwait	23,000	2.2
Lebanon	124,000	12.2
Saudi Arabia	89,000	8.7
Syria	79,000	7.8
Yemen	41,000	4.0
Other Western Asia	73,000	7.2
North Africa	322,000	31.7
Egypt	176,000	17.4
Morocco	64,000	6.3
Sudan	41,000	4.0
Other Northern Africa	41,000	4.0
MENA Total	1,017,000	100

Source: Zong and Batalova, 2015.

California has been is the main immigration destination for people coming from the MENA (20%). Michigan and New York follow at 11% and 10% respectively. Between the years 2009 and 2013, the top counties receiving MENA immigrants were Los Angeles County in California, Wayne County in Michigan, Cook County in Illinois and Kings Country in New York. Nineteen percent of MENA immigrants were accounted for in the four previously mentioned counties. During the same time period (2009-2013) the following three cities had the largest pool of MENA immigrants residing within them: New York City, Los Angeles and Detroit metropolitan areas. These three cities hosted roughly one-third of MENA immigrants within the whole of the United States (Zong and Batalova, 2015).

Table 2 Top Concentrations by Metropolitan Area for the Foreign Born from the MENA Region, 2009-13

Metropolitan Area	Immigrant Population from the MENA Region	% of Metro Area Population
New York-Newark-Jersey City, NY-NJ-PA	126,000	0.6%
Los Angeles-Long Beach-Anaheim, CA	87,000	0.7%
Detroit-Warren-Dearborn, MI	83,000	1.9%
Chicago-Naperville-Elgin, IL-IN-WI	42,000	0.4%
Washington-Arlington-Alexandria, DC-VA-MD-WV	37,000	0.6%
San Diego-Carlsbad, CA	25,000	0.8%
Boston-Cambridge-Newton, MA-NH	24,000	0.5%
Houston-The Woodlands-Sugar Land, TX	22,000	0.4%
San Francisco	16,000	0.4%
Dallas-Fort Worth-Arlington, TX	15,000	0.2%

Source: Zong and Batalova, 2015.

MENA immigrants were more likely to be employed in management, business, science, and arts occupations (41 percent) and sales and office occupations (26 percent) than both the overall foreign-born (30 percent and 17 percent) and native-born (38 percent and 26 percent) populations (Zong and Batalova 2015).

3. Approach and Data

We measure the contribution of immigrants to national technological capacity with patent data following the approach of Kerr (Kerr, 2008; Kerr and Lincoln, 2010). Dernis and Guellec (2001, p.130) sum up the characteristics of patents: “A patent is an intellectual property right relating to inventions in the technical field. A patent may be granted to a firm, individual or public body by a patent office. An application for a patent has to meet certain requirements: the invention must be novel, involve a (non-obvious) inventive step and be capable of industrial application. Among the few available indicators of technology output, patent-based indicators are probably the most frequently used“. Patents protect the rights of the inventor(s) as well as those of the applicant(s). Thus, patent documents provide the names of inventor(s) including the place of residence.

We use patent documents filed under the Patent Cooperation Treaty (PCT) by the World International Property Organization provided by the OECD, REGPAT database, February 2016. The PCT allows firms and individuals to protect their inventions simultaneously for a large number of countries by filing a single PCT patent application instead of applying at various national patent offices. PCT currently includes 145 contracting states. We match the first name of a particular inventor with a list of MENA specific first names (Kerr, in contrast, uses family names).

This names list has been generated by collecting common first names of people from MENA countries from secondary sources. In a second step, we matched this list with names of patent inventors frequently used in MENA countries. From both sources, we excluded first names that were

obviously not MENA-specific or ambiguous (e.g. abbreviations) names. This way we were able to construct a set of 2,475 typical MENA first names.

In a next step, we compared the share of the patents associated with inventors with typical MENA names to the total number of patents on the level of countries worldwide for the whole time period with PCT patent data available (1978 to 2014) covering almost 2.7 million patents with 7.1 million inventors. 1,240 of the typical MENA first names had at least one inventor of a PCT patent associated, residing in 108 different countries. While the share was 73.7% in the MENA region, the share was only 1.35% outside the MENA region. On the country level, 27.4% (United Arab Emirates) to 88.5% (Iran) of all patents in each country of the MENA region were associated to one of the typical MENA names while in all non-MENA countries (except some neighboring countries with very low numbers of total patents) the highest share was found in Canada with 3.11%, indicating that the initial name list correctly worked as a proxy for MENA inventors on the global scale. The list of typical MENA names resulted in a worldwide share of 1.57% of MENA inventors on total patent inventions worldwide.

To ensure that every name is not just typical for the MENA region, but also specific for only the region, we checked quantitatively if any of these 1240 names from the initial set with at least one patent inventor occurred in any non-MENA country significantly more often than expected or is significantly less often used in the MENA region as a whole than expected, detecting 138 names with the potential to be not specific enough. However, in some cases a high occurrence of a single name in a non-MENA country was caused by a) specific migration patterns (e.g. Turkish names in Germany), b) host country specific transliterations or, c) highly active single MENA inventors and the name therefore kept. A low occurrence of some names in the MENA region also does not necessarily indicate that the name is not specific enough but can also be caused by a very low level of patenting in the country of origin of the specific name. This low occurrence was the case for a number of Persian names, patents of inventors of Persian origin are almost exclusively found in patents of diaspora inventors. Therefore we kept 82 of the names and removed the remaining 55 names. It is important to note that we only used exact matches and no similar names to ensure that we include just specific names.

The final set of 2,419 MENA-specific first names therefore only includes first names that are specific to the MENA region and not widely used (except for migrants with a MENA background) in other regions of the world. While we only excluded about 2% of the initial names, we improved the quality of the name set significantly and reduced the number of patents associated to inventors with MENA-specific names to 1.08% of all patents worldwide, a total of 28,750 patents. About 80% of these patents were invented outside the MENA region. This exclusion of non-specific names reduced the share of MENA inventors outside the MENA region from 1.35% to 0.86%, while the corresponding share within the MENA region remained with 69.7% still high. On the country level, shares vary between 87.0% (Iran) and 26.6% (United Arab Emirates). As expected, countries without a significant immigration from the MENA region reveal very low shares of patents associated to MENA inventors (e.g. China, Korea or Japan with shares of 0.03 to 0.04%), while countries with a significant MENA diaspora have much higher shares. Canada reveals the highest share of any non-majority Muslim country with 2.48%.

The final set of 2,419 MENA-specific – and not just typical – first names ensure that our estimates can be considered as a lower limit of patenting activities of migrants with a MENA background.

The use of first names as a filter produces both overestimates and underestimates. Many people in the MENA region have non-Middle Eastern specific names such as George, Sami or Joseph. Furthermore, many Muslims from outside the MENA region, from Pakistan, Indonesia or Nigeria, will have names that are common with the MENA region. However, this overlap in names in low and with the exception of Pakistan, all non-MENA countries have calculated shares of MENA inventors well below all MENA countries.

Nevertheless, we believe that the data capture largely the contribution of people originating from the MENA region and to a certain extent from Muslim countries.

There are two principle ways of counting patents, both reflecting a different approach to the data. First, we can count all patents with **at least one** inventor with a MENA background (full counts). Second, we can split each patent count by the number of inventors assigned to the patent (fractional counts). If, for example, an engineer with a MENA background is the co-inventor of a patent together with three other persons, we will count this only as a ¼ of a patent. We will provide full counts only for comparison on the aggregate level and mostly apply fractional counts in the analysis.

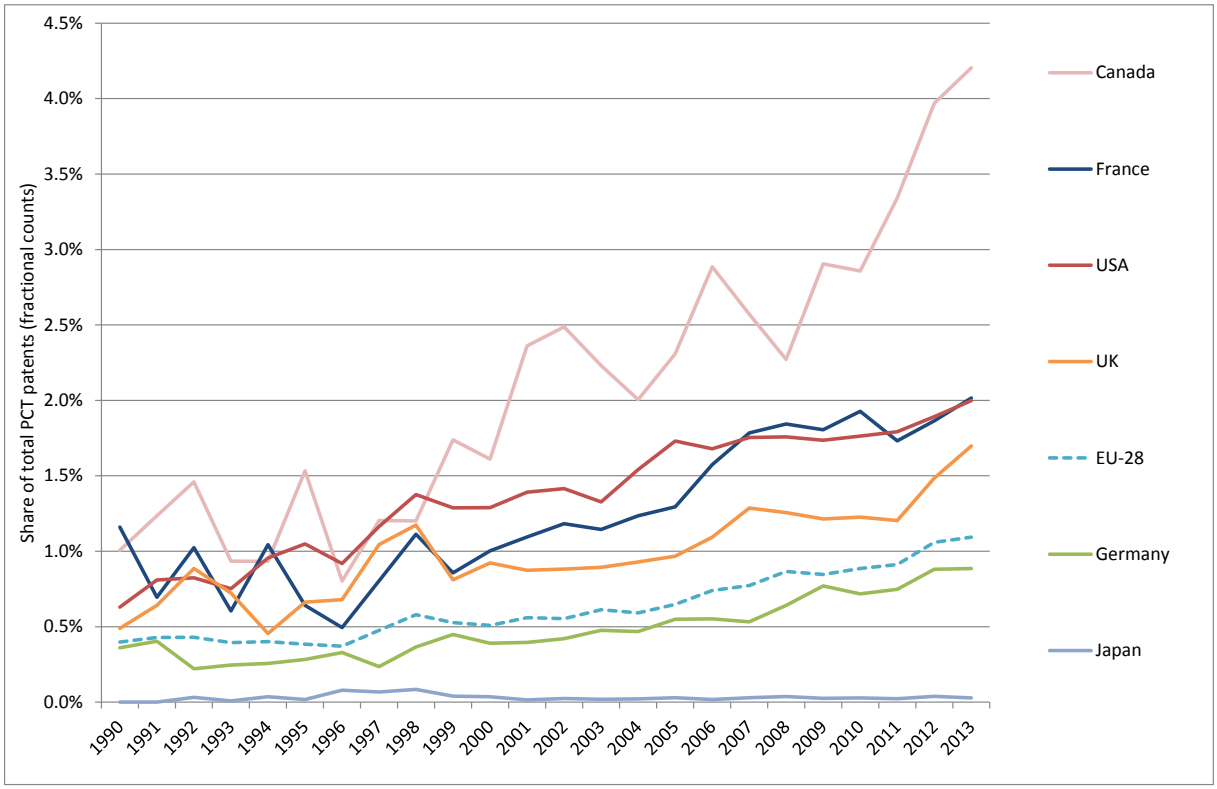
4. **Results**

The aggregate Level

In the five years period 2009-2013, we found 12,137 single PCT patent applications by US organizations or individuals residing in the US with at least one inventor with a MENA background (full counts). This represents 4.7% of all PCT patent applications with at least a person residing in the US, compared with a share of persons with a MENA background of merely 0.6 percent of the total population. If fractional counts are applied, inventors with a MENA-background account for 4,507 patents in this time period, a share of 1.8% on total patenting in the US.

Figure 1 below describes the development of the share of inventors with a MENA background (fractional counts) over time and compares the relevance of this group for innovation in the US with the European Union (EU-28) and Canada, Germany, France, the United Kingdom and Japan.

Figure 1: Share of patents with an MENA-background on total PCT patents inventions, 1990-2013



Source: OECD, REGPAT database, February 2016, own calculations.

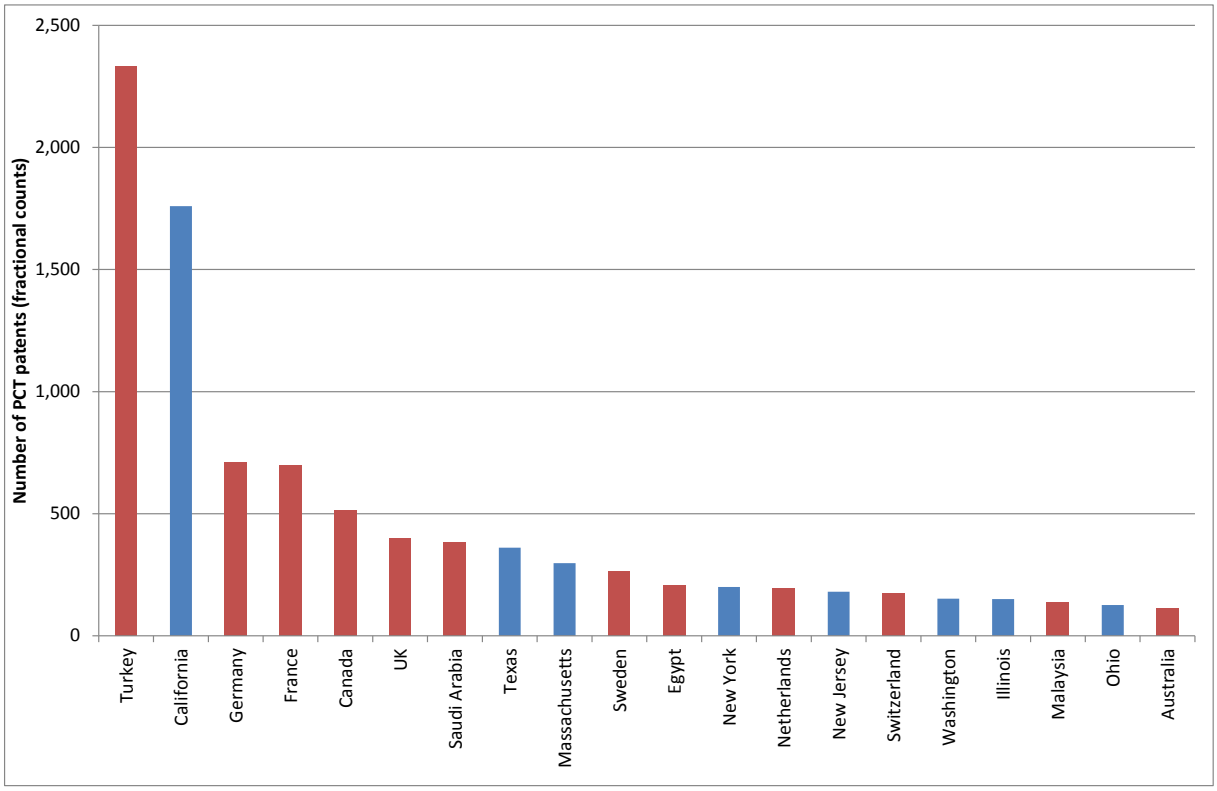
The US, Canada and France are the most attractive places for innovators with a MENA background. The share for the European Union (EU-28) is around half the value of the US, which corresponds to 2,514 patent applications 2009 to 2013. While Canada has the highest share of patents with MENA inventors, the absolute number (512) is well below the US level. There is a clear upward trend in all countries depict in the Figure, except Japan, which indicates that knowledge from abroad becomes more important over time. However, it seems that the US innovation system is better able to attract talent and knowledge from abroad than most other countries. In the European Union, Germany, France and the UK together account for 72% of all patents with a MENA inventor.

Germany has a higher total number than France, but a smaller share due to a higher overall number of PCT patent applications. The small share of Germany may be explained by the attractiveness of the country for other groups of high-skilled immigrants, for example from Eastern Europe. Moreover, immigrants in Germany are on average less educated than in France or the UK, with a share of highly skilled of 29% in Germany compared to 36% in France and 47% in the UK (OECD/European Union 2015). Japan has – as expected – virtually no patents with inventors with MENA-background.

The data also allow to identify the geographical focus of inventors with MENA background in the US. The State of California alone – with 1,760 patents (fractional count) – holds a share of about 15% of all patents with a MENA background worldwide. This is considerably more than the corresponding number of all European countries and of all MENA countries including Saudi Arabia, Egypt or the Gulf states. Only Turkey has a larger number of inventors with MENA background. Other US states with a notable number of patent inventors with a MENA background are Texas and Massachusetts. The State of Texas has only slightly less inventors with MENA background than Saudi

Arabia. Even within the state of California we can observe a strong concentration in two locations: Santa Clara County (571 patents), San Diego County (505 patents). Santa Clara County has more inventors with MENA background than any MENA country except Turkey.

Figure 2: Number of patent inventors with an MENA-background in countries (red) and US states (blue) 2009-2013

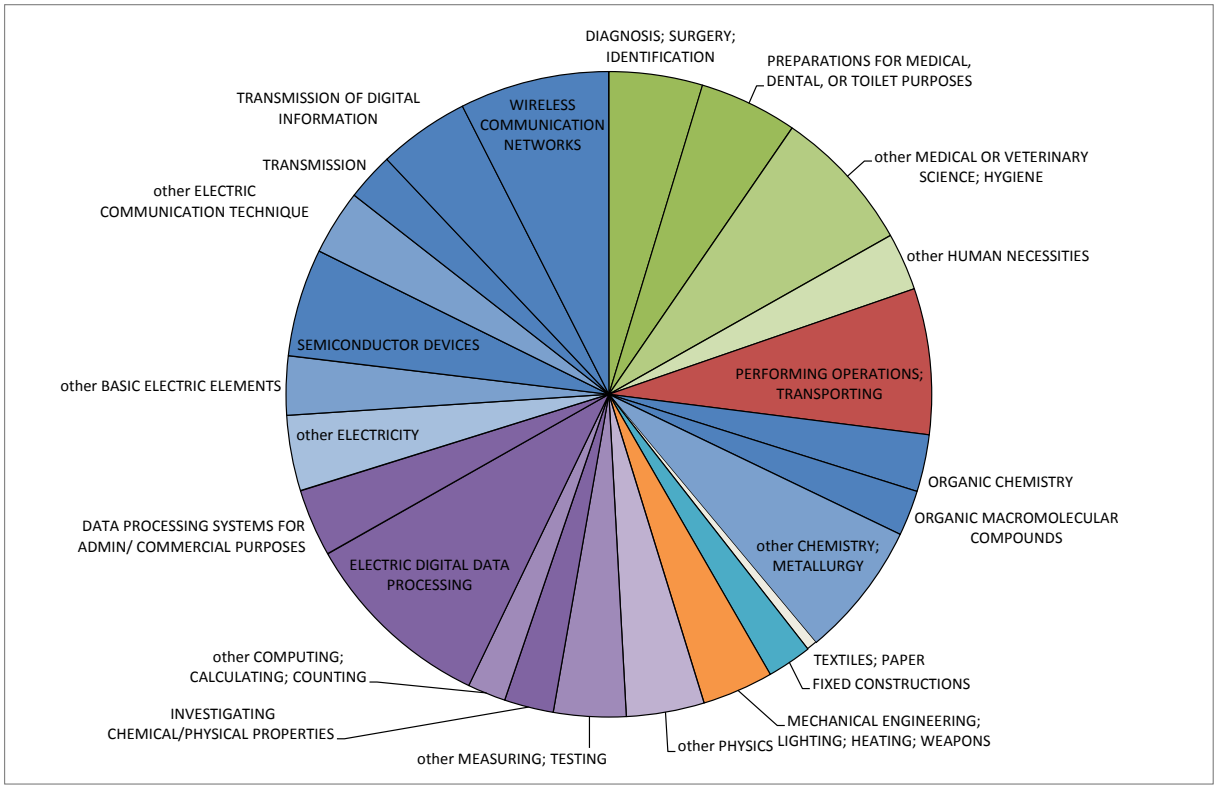


Note: Blue: US states, Red: countries

Source: OECD, REGPAT database, February 2016, own calculations.

The geographical focus on California is an indication that scientists and engineers from the Middle East mainly contribute to America's tech scene in Silicon Valley. US based MENA inventors indeed tend to concentrate in the field of computers, communication and software (Figure 3 below). The data (in fractional counts) show an above-average technological specialization in electrical and communication technologies, computing technologies, and basic electronic circuitry. In all these fields, the share of inventors with a MENA background is well above 2% (see table x in the Annex). This finding suggests that firms active in these domains are set to lose from an immigration regime and a political climate that are hard on people of MENA origin. We also find a similar specialization of inventors with a MENA background in computers, communication and software in the European Union. Another technological field with a large number of MENA inventors is medical and veterinary sciences. However, since medical science is one of the largest fields overall, MENA inventors reveal only an average specialization.

Figure 3: Share of different technologies on overall patent inventions of inventors with an MENA-background, United States, 2009-2013



Source: World Intellectual Patent Organization, own calculations.

The firm level

Kerr et al. (2015) argue that the firm is, for various reasons, an important level of analysis for studying high-skilled immigration: firms play a vital role in the immigration process for highly-skilled because in the US H-1B visa programme; the firm selects the worker it wants to hire, not the other way around like in the case of hiring through the labour market. Moreover, the immigrant is tied to the firm until he/she obtains permanent residency.

Using the same dataset we are able to investigate the distribution of MENA originating inventors and their affiliation with the top US technology companies. What we see is that the top 20 patent inventors have an above average share of inventors with a MENA background, suggesting that these companies would indeed be affected from a more restrictive Middle East immigration policy. While these companies account for 19% of all patents invented in the US, they employ 25% of the MENA inventors. The data also reveal that the share of MENA inventors differs considerably across the top 20 US technology firms. We find the highest shares in particular in the semiconductors industry with Intel having the highest share (and the second highest absolute number) and Qualcomm the highest number (and second highest share) of MENA inventors. These two technology companies are particularly vulnerable to a change in US immigration and visa policy. It is worth noting again here that these are fractional counts, meaning that a patent that has 5 inventors on it of which only one with a MENA specific name is counted as 1/5 patent. So, the absolute numbers of patents with a MENA relation are about three to four times bigger.

Table 3: Top 20 US technology firms and share of inventors with MENA background, 2009-2013

Company	Total	MENA background	MENA share
Intel	3,595	166	4.6%
Qualcomm	9,677	392	4.1%
Applied Materials	1,294	44	3.4%
Apple	1,927	59	3.1%
Schlumberger	898	25	2.8%
Microsoft	3,848	98	2.5%
IBM	1,752	36	2.0%
Johnson & Johnson**	1,519	25	1.7%
Google	2,240	38	1.7%
HP	2,688	43	1.6%
General Electric	1,582	26	1.6%
Halliburton	2,240	33	1.5%
Dow Chemical Company*	2,177	32	1.4%
Procter & Gamble	1,472	19	1.3%
Baker Hughes	1,,456	19	1.3%
DuPont	1,447	15	1.0%
3M	2,211	22	1.0%
Merck Sharp & Dohme	791	7	0.9%
United Technologies	1,828	11	0.6%
Corning*	1,450	6	0.4%
Top 20 Total	**46,093**	1,116	2.4%
US Total	244,174	4,507	1.8%
Share of Total	19%	25%	

*Dow Corning included in Dow Chemicals, planned merger of Dow Chemicals and DuPont (DowDuPont) not

**including Ethicon and Janssen

Source: World Intellectual Patent Organization, own calculations.

Table 4 below combines the firm level data with the technology level for the five companies out of the Top 20 US technology firms with the highest share of MENA inventors, namely Qualcomm, Intel, Applied Materials, Apple and Schlumberger. Data for all five companies shows that patents with MENA inventors are within the very core competencies of their businesses, between 70% and 86% of all patents with MENA inventors are within the five most important technologies for each firm. We can also observe some common patterns on the technology level, in particular in Wireless communication networks, a core technology for Qualcomm, Intel and Apple; MENA inventors are highly overrepresented in each case with shares of 6 to 9% of all patent inventors.

Table 4: Share of inventors with MENA background on the technology level (IPC subclass and IPC group), 2009-2013

Qualcomm	Total	MENA background	MENA share
1. WIRELESS COMMUNICATION NETWORKS	3,079	180	5.9%
1.1 Local resource management	422	27	6.3%

1.2 Power management	409	34	8.3%
2. TRANSMISSION OF DIGITAL INFORMATION	1,374	47	3.4%
2.1 Arrangements for detecting or preventing	335	12	3.7%
2.2. Arrangements, apparatus, circuits or systems,	328	11	3.3%
3. ELECTRIC DIGITAL DATA PROCESSING	933	25	2.6%
4. PICTORIAL COMMUNICATION	821	17	2.1%
4.1 Television systems	371	13	3.5%
5. BROADCAST COMMUNICATION	626	29	4.7%
Top 5 IPC subclasses Total	6,833	298	4.4%
Qualcomm total	**9,677**	**392**	**4.1%**
Top 5 subclasses share of total	71%	76%	
Top subclass share of total	32%	46%	

Intel	**Total**	**MENA background**	**MENA share**
1. ELECTRIC DIGITAL DATA PROCESSING	1266	32	2.6%
1.1 Arrangements for programme control	316	9	2.9%
1.2 Interconnection of memories, input/output	216	4	1.9%
1.3 Details not covered by other groups	185	5	3.0%
1.4 Security arrangements against unauthorised	143	4	2.6%
2. WIRELESS COMMUNICATION NETWORKS	533	46	8.7%
3. SEMICONDUCTOR DEVICES	395	19	4.8%
3.1 Processes for the manufacture of semiconductor	180	9	4.9%
4. TRANSMISSION OF DIGITAL INFORMATION	252	21	8.3%
5. BROADCAST COMMUNICATION	192	18	9.2%
Top 5 IPC subclasses Total	2638	136	5.2%
Intel total	3595	166	4.6%
Top 5 subclasses share of total	73%	82%	
Top subclass share of total	35%	20%	

Applied Materials	**Total**	**MENA background**	**MENA share**
1. SEMICONDUCTOR DEVICES	953	26	2.8%
1.1 Processes for the manufacture of semiconductor	835	23	2.8%
1.2 Semiconductor devices sensitive to infra-red	71	2	3.4%
2. COATING METALLIC MATERIAL	102	5	5.2%
2.1 Chemical coating by decomposition of gaseous	59	2	3.4%
2.2 Coating by vacuum evaporation	39	3	7.7%
3. PLASMA TECHNIQUE	40	5	12.2%
3.2 Generating/Handling plasma	40	5	12.2%
5. DIRECT CONVERSION OF CHEMICAL ENERGY INTO ELECTRICAL ENERY (e.g. BATTERIES)	39	1	3.6%
6. ELECTRIC DIGITAL DATA PROCESSING	13	0	0.0%
Top 5 IPC subclasses Total	1148	38	3.3%
Applied Materials total	**1294**	**44**	**3.4%**
Top 5 subclasses share of total	89%	87%	
Top subclass share of total	74%	61%	

Source: World Intellectual Patent Organization. own calculations.

Apple	Total	MENA background	MENA share
1. ELECTRIC DIGITAL DATA PROCESSING	669	19	2.8%
1.1 Input/Output arrangements for transferring data	267	13	4.9%
1.2 Details not covered by other groups	124	1	0.9%
1.3 Arrangements for programme control	79	3	3.7%
1.4 Digital computing equipment	78	1	1.5%
2. WIRELESS COMMUNICATION NETWORKS	199	13	6.6%
3. PICTORIAL COMMUNICATION	100	0	0.2%
4. TRANSMISSION OF DIGITAL INFORMATION	97	5	5.3%
5. ARRANGEMENTS OR CIRCUITS FOR CONTROL OF	69	4	5.2%
5.1 Control arrangements or circuits, in connection with visual indicators other than cathode-ray tubes	54	4	6.8%
Top 5 IPC subclasses Total	1927	57	3.6%
Apple total	**59%**	**70%**	**3.1%**
Top 5 subclasses share of total	59%	70%	
Top subclass share of total	35%	32%	

Schlumberger	Total	MENA background	MENA share
1. EARTH OR ROCK DRILLING	501	12	2.5%
1.1 Survey of boreholes or wells	116	3	2.9%
1.2 Methods for obtaining oil, gas etc.	107	1	1.2%
1.3 Testing the nature of borehole walls	45	1	2.7%
2. GEOPHYSICS	152	4	2.9%
2.1 Electric or magnetic prospecting or detecting	53	2	4.2%
3. MATERIALS FOR APPLICATIONS NOT OTHERWISE	54	4	7.4%
3.1Compositions for drilling of boreholes or wells	54	4	7.5%
4. INVESTIGATING MATERIALS BY DETERMINING	33	1	1.6%
5. ELECTRIC DIGITAL DATA PROCESSING	18	1	3.4%
Top 5 IPC subclasses Total	758	22	2.9%
Schlumberger total	**898**	**25**	**2.8%**
Top 5 subclasses share of total	84%	87%	
Top subclass share of total	56%	49%	

Technological specialization of MENA inventors in the US

Finally, we investigate the technological specialisation of inventors with a MENA background in the US in more detail. We start with comparing their technological specialisation with that of all patents invented in the US, and, in a second step, with that of the MENA region.

Given the objective of this analysis, a measurement approach is needed which captures relative specialisation advantages in specific technologies to identify strengths and weaknesses of the R&D activities of inventors with a MENA background relative to their host country. The Revealed Technological Advantage index (RTA) fulfils these criteria. The index for a specific technology field k for inventor group i is defined by:

$$RTA_{ik} = \frac{p_{ik}}{\sum_{i=1}^{n} p_{ik}} \Bigg/ \frac{\sum_{k=1}^{m} p_{ik}}{\sum_{i=1}^{n}\sum_{k=1}^{m} p_{ik}} \qquad (1)$$

where p denotes the number of patent applications, i=1, …, n indexes the inventor groups, k=1, …, m the technology class. The RTA index for the MENA inventors and the respective technology field compared to total US is calculated as the ratio between the number of patent applications of MENA inventors in the specific technology field and the sum of all patent applications by MENA inventors, multiplied by the sum of all patent applications in the US divided by the sum of overall patent applications in the selected technology field. Note that the RTA index varies around unity, i.e. values above unity indicate relative technological advantages in the specific technology field whereas values below unity are pointing out relative technological disadvantages (Vertova, 1999). If all index values would be close to 1, the technological specialisation of MENA-inventors in the US would completely mirror the total US technological specialisation.

The results are summarized in the first column of the table below. In particular, technologies within the broad field of Electricity - most notable Wireless Communication Networks - show very high RTA index values, indicating that MENA inventors are more specialised in these technologies than the US as a whole. While there is also a slight specialisation in other ICT related technologies, MENA inventors are underrepresented in transport and mechanical engineering.

How does this distinct specialisation pattern compare to the specialisation of the home region and can the specialisation of MENA inventors be explained by that? The second column in the table below compares - in the same way as with total US patenting - patent inventions of MENA inventors in the US with patents invented in the MENA region, therefore comparing their specialisation with the distribution of patents in their home region. The RCA index values reveal that MENA inventors in the US are much more specialised in ICT than their home region is, while the relative importance of most other technologies, including transport or mechanical engineering, is much lower among migrant inventors with a MENA background than in the MENA region. Therefore, the relative specialisation of MENA inventors in the US compared to US total **cannot** be explained by the home region specialization.

Table 5: Technological specialisation of inventors with MENA background in the US compared to US total and patents in the MENA-region, 2009-2013

	Specialisation (RTA-Index) of Inventors with MENA-background in the US	
Technology	**compared to total US**	**compared to MENA-region**
A - HUMAN NECESSITIES	0.9	0.8
A61 - MEDICAL OR VETERINARY SCIENCE; HYGIENE	1.0	1.0
A61B - DIAGNOSIS; SURGERY; IDENTIFICATION	1.1	2.0
A61K - PREPARATIONS FOR MEDICAL, DENTAL, OR TOILET PURPOSES	0.9	0.5
B - PERFORMING OPERATIONS; TRANSPORTING	0.7	0.7

C - CHEMISTRY; METALLURGY	0.9		1.0
C07 - ORGANIC CHEMISTRY	0.8		1.7
C08 - ORGANIC MACROMOLECULAR COMPOUNDS	1.1		1.1
D - TEXTILES; PAPER	0.8		0.1
E - FIXED CONSTRUCTIONS	0.7		0.3
F - MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS; BLASTING	0.6		0.2
G - PHYSICS	1.1		1.7
G01 - MEASURING; TESTING	1.1		1.3
G01N - INVESTIGATING CHEMICAL/PHYSICAL PROPERTIES	0.9		1.5
G06 - COMPUTING; CALCULATING; COUNTING	1.2		2.2
G06F - ELECTRIC DIGITAL DATA PROCESSING	1.2		2.7
G06Q - DATA PROCESSING SYSTEMS FOR ADMIN/COMMERCIAL PURPOSES	1.2		2.0
H - ELECTRICITY	1.5		3.2
H01 - BASIC ELECTRIC ELEMENTS	1.3		3.7
H01L - SEMICONDUCTOR DEVICES	1.5		6.7
H04 - ELECTRIC COMMUNICATION TECHNIQUE	1.8		4.3
H04B - TRANSMISSION	2.3		7.0
H04L - TRANSMISSION OF DIGITAL INFORMATION	1.6		5.3
H04W - WIRELESS COMMUNICATION NETWORKS	2.5		6.5
Total	1.0		1.0

There are a number of possible explanations for these specialisation patterns of inventors with a MENA background in the US. First, it may be that immigration of these engineers is triggered by a lack of adequate employment opportunities in their countries of origin, was indicated by the low specialisation of these countries in ICT. So,the lack of patenting activities in these fields in the MENA region can be considered as a push factor for skilled labour in the related technologies to seek for employment abroad.

Second, the fast growth of US tech companies analyzed above may force these companies to actively source for talent abroad as they cannot meet their demand for skilled workers domestically. While some of the firms analysed, e.g. Intel, have significant R&D facilities outside the US, others, most notable Qualcomm, still perform their R&D almost entirely within the US. International labour sourcing can in this case be a substitute for the relocation of R&D to locations abroad. Qualcomm increased the number of its patents by 470% in a five-year period, from 1,769 in the period 1999-2003 to 9,678 in 2009-2013 but still has a 99% of its inventors residing in the US.

Another explanation for the diverging specialisation pattern between the MENA region and MENA inventors in the US are different country distributions between patents in the MENA region and migration to the US. Turkey accounts for 61% of all patents invented in the MENA region and Saudi Arabia contributes another 14%, while these two countries only contribute moderate shares to total MENA-migration in the US. At the same time, the Iran has only a 1% share on all patents invented in the MENA region and countries including Iraq, Jordan or Syria even less while they contribute significant share to the US population with a MENA population (see Table 1).

4. Discussion and conclusions

We investigated the technological activities of inventors with a Middle East/North African (MENA) background in the United States and Europe with patent data. The contribution of this group of inventors to overall US patent activity increased considerable in the last 20 years, although their share is still below the share of inventors with Chinese or Indian background reported by Kerr and others. Inventors with a MENA background have a higher share on overall inventive activity in the United States than in Europe, which indicates a higher attractiveness of the US innovation system. Moreover, there are considerably more inventors with a MENA background in the US than in the MENA region itself.

The literature on migrant inventors identifies different positive effects of migrant inventors on their host countries. First, they contribute to the stock of knowledge of their employer companies by their inventive activities. In this paper, we showed that migrant innovators from the MENA region considerably contribute to the capabilities of major US companies in information and communication technologies. Second, migrant inventors utilize their networks and contacts to individuals and organisations in their countries of origin for the benefit of the firm. Breschi et al. (2015) show that inventors from a similar ethnic background cite their works more often, and help firms to gain knowledge from other ethnic inventors through the international diaspora effect. We did not engage in a patent citation analysis to be able to establish such an effect. However, by looking at the patent specialisation profiles of MENA based inventors and US-based inventors, we were able to establish that they differ from each other and hence the opportunity for knowledge transfer is weaker. US based MENA inventors tend to be active in technologies that are different from those of their peers in the MENA region. We interpret this specialisation pattern as a sign that US technology companies try to source knowledge from a number of world regions, irrespectively of their technological specialisation. US-based MENA inventors are active in technology areas that are considered core competencies for US firms. In that sense, they are critical to their US employers' competitiveness.

Finally, beyond technological knowledge, Foley and Kerr (2013) indicate that migrant inventors are a source of information on market opportunities in their home countries. More innovators with a particular ethnic background relate to a stronger engagement of their US companies in terms of sales, employment, assets, and R&D activities in these countries. While our paper did not seek to examine this claim, trade data suggest that a similar dynamics might be at play with the MENA region too. According to data by the US Department of Commerce[1], about 4.8% of US exports go to the Middle East (excluding Israel) in 2015. This is significantly a larger than the share of MENA immigrants in US population, which is estimated at 2 million or 0.6% of population and closer to their share of patenting. Furthermore, computers and electronics products come second only to transport equipment in US exports to the MENA region (ca. 6.7 billion USD or 11% of total annual exports to MENA excluding Israel). However, further research will be required to establish whether such a link exists.

[1] Trade Policy Information System (TPIS): http://tpis2.trade.gov/TPIS_PUBLIC/tpis_ctysel1.aspx#TPISDataTable

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Annex

Table x: Share of inventors with MENA background on the technology level, 2009-2013

Technology	Total I	MENA background	MENA share
A - HUMAN NECESSITIES	55,179	888	1.6%
A61 - MEDICAL OR VETERINARY SCIENCE; HYGIENE	41,936	758	1.8%
A61B - DIAGNOSIS; SURGERY; IDENTIFICATION	9,986	211	2.1%
A61K - PREPARATIONS FOR MEDICAL, DENTAL, OR TOILET PURPOSES	13,254	221	1.7%
B - PERFORMING OPERATIONS; TRANSPORTING	25,541	329	1.3%
C - CHEMISTRY; METALLURGY	34,007	538	1.6%
C07 - ORGANIC CHEMISTRY	8,647	129	1.5%
C08 - ORGANIC MACROMOLECULAR COMPOUNDS	4,872	102	2.1%
D - TEXTILES; PAPER	1,513	23	1.5%
E - FIXED CONSTRUCTIONS	8,382	101	1.2%
F - MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS; BLASTING	15,479	160	1.0%
G - PHYSICS	56,664	1,123	2.0%
G01 - MEASURING; TESTING	13,641	274	2.0%
G01N - INVESTIGATING CHEMICAL/PHYSICAL PROPERTIES	6,522	111	1.7%
G06 - COMPUTING; CALCULATING; COUNTING	31,052	674	2.2%
G06F - ELECTRIC DIGITAL DATA PROCESSING	20,189	435	2.2%
G06Q - DATA PROCESSING SYSTEMS FOR ADMIN/COMMERCIAL PURPOSES	7,179	153	2.1%
H - ELECTRICITY	47,376	1,344	2.8%
H01 - BASIC ELECTRIC ELEMENTS	15,983	376	2.4%
H01L - SEMICONDUCTOR DEVICES	8,621	243	2.8%
H04 - ELECTRIC COMMUNICATION TECHNIQUE	24,118	797	3.3%
H04B - TRANSMISSION	2,590	108	4.2%
H04L - TRANSMISSION OF DIGITAL INFORMATION	6,928	206	3.0%
H04W - WIRELESS COMMUNICATION NETWORKS	7,412	337	4.5%
Total	**244142**	**4506**	1.8%