LinkedIn & IFC study of migration

Luisa M Mimmi

November 24, 2017

1 CONCEPTUAL FRAMEWORK

A city's productivity can be simply defined as the net result of contrasting forces $Productivity = Agglomeration(positive) - Congestion(negative)$

Where $Agglomeration$ and $Congestion$ are a function of various dimensions $= f(Skills, Amenities, Form, Access)$

- Dimensions
  - **Skills**, a city's aggregate stock of human capital
  - **Amenities** - *attracting skills* - job opportunities, housing values, cultural attractions
  - **Form**, the size and spatial configuration of a city (*density* vs. *sprawl*, *wider metropolitan areas*)
  - **Access**, a city's connectedness (or barriers) to other cities, both at home and abroad, through the transportation network
- This comparative analysis will focus on the first dimension **Skills**, with hints to the other ones

```
library(ggplot2) # install.packages("ggplot2")
library(dplyr)
library(knitr)
library(datasets) # initialize
library(knitr)
library(kableExtra)
library(stats)
library(tidyr)
library(stringr)
library(stats)
```

```
# getwd()
# migr <- read.csv("migration.csv",fileEncoding="UTF-8-BOM")
# demog <- read.csv("demographics.csv",fileEncoding="UTF-8-BOM")

load(here::here(".","migr.Rdata"))
load(here::here(".","demog.Rdata"))
```

2 DATA EXPLORATION BY COUNTRY

2.a Preliminary check on demog and migr

```
#   names(demog)      #see all header (column) names
demog[1:5,]          # Indexing (1st to 5 th rows only)
```

```
##   NEW_MEM_ID HIGHEST_DEGREE_OBTAINED SENIORITY        EMPLOYER_INDUSTRY_SECTOR
## 1          1                  doctor     Entry  Financial Services & Insurance
## 2          2                  doctor   Partner      Architecture & Engineering
```

```
## 3          3                bachelor       CXO      Retail & Consumer Products
## 4          4                  master     Entry           Technology - Hardware
## 5          5                  master    Senior Government/Education/Non-profit
##         POSITION_FUNCTION
## 1 Information Technology
## 2   Business Development
## 3   Business Development
## 4 Information Technology
## 5              Education
```

```r
str(demog)
```

```
## 'data.frame':    475316 obs. of  5 variables:
##  $ NEW_MEM_ID              : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ HIGHEST_DEGREE_OBTAINED : Factor w/ 4 levels "associate","bachelor",..: 3 3 2 4 4 2 2 2 4 3 ...
##  $ SENIORITY               : Factor w/ 11 levels "CXO","Director",..: 3 6 1 3 7 11 7 1 4 4 ...
##  $ EMPLOYER_INDUSTRY_SECTOR: Factor w/ 14 levels "Aero/Auto/Transport",..: 3 2 10 12 4 14 7 7 4 4 ..
##  $ POSITION_FUNCTION       : Factor w/ 26 levels "Accounting","Administrative",..: 13 4 4 13 7 18 16
```

```r
summary(demog)       #see some summary statistics of each column
```

```
##    NEW_MEM_ID     HIGHEST_DEGREE_OBTAINED    SENIORITY
##  Min.   :     1   associate: 81072        Entry   :220187
##  1st Qu.:118830   bachelor :252952        Senior  :146986
##  Median :237658   doctor   : 40502        Manager : 46279
##  Mean   :237658   master   :100790        Training: 22047
##  3rd Qu.:356487                           Director: 21093
##  Max.   :475316                           VP      :  7884
##                                           (Other) : 10840
##                     EMPLOYER_INDUSTRY_SECTOR              POSITION_FUNCTION
##  Government/Education/Non-profit: 85999      Engineering           : 53792
##  Technology - Software          : 65725      Education             : 41195
##  Healthcare & Pharmaceutical    : 63281      Sales                 : 39617
##  Professional Services          : 60623      Operations            : 36840
##  Financial Services & Insurance : 48297      Research              : 31635
##  Retail & Consumer Products     : 36494      Information Technology: 31435
##  (Other)                        :114897      (Other)               :240802
```

```r
#  sapply(demog, class)   # get class of all columns

#   names(migr)      #see all header (column) names
migr[1:5,]          # Indexing (1st to 5 th rows only)
```

```
##   NEW_MEM_ID WEEK_BEGINNING SOURCE_COUNTRY              SOURCE_REGION
## 1          1      1/31/2016  United States     San Francisco Bay Area
## 2          2      9/18/2016  United States Greater New York City Area
## 3          3      5/22/2016  United States     San Francisco Bay Area
## 4          4      7/24/2016  United States       Greater Detroit Area
## 5          5      1/24/2016  United States Greater New York City Area
##   DESTINATION_COUNTRY        DESTINATION_REGION
## 1       United States Greater Philadelphia Area
## 2      United Kingdom    London, United Kingdom
## 3       United States    Dallas/Fort Worth Area
## 4       United States       Greater Boston Area
## 5       United States    San Francisco Bay Area
```

```r
str(migr)
```

```
## 'data.frame':    475316 obs. of  6 variables:
##  $ NEW_MEM_ID         : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ WEEK_BEGINNING     : Factor w/ 53 levels "1/10/2016","1/17/2016",..: 5 51 34 43 3 45 52 31 46 46
##  $ SOURCE_COUNTRY     : Factor w/ 3 levels "Australia","United Kingdom",..: 3 3 3 3 3 3 3 3 3 3 ...
##  $ SOURCE_REGION      : Factor w/ 347 levels "Aberdeen, United Kingdom",..: 272 126 272 118 126 333 
##  $ DESTINATION_COUNTRY: Factor w/ 3 levels "Australia","United Kingdom",..: 3 2 3 3 3 3 3 3 3 3 ...
##  $ DESTINATION_REGION : Factor w/ 282 levels "Abilene, Texas Area",..: 106 157 61 93 222 168 104 11 
```

```r
summary(migr)       #see some summary statistics of each column
```

```
##    NEW_MEM_ID       WEEK_BEGINNING         SOURCE_COUNTRY
##  Min.   :     1   7/31/2016: 11460   Australia     :  8902
##  1st Qu.:118830   8/21/2016: 11433   United Kingdom: 36615
##  Median :237658   8/14/2016: 11384   United States :429799
##  Mean   :237658   9/11/2016: 11184
##  3rd Qu.:356487   8/28/2016: 11182
##  Max.   :475316   8/7/2016 : 10916
##                   (Other)  :407757
##                     SOURCE_REGION        DESTINATION_COUNTRY
##  Greater New York City Area: 37000   Australia     :  8647
##  Greater Los Angeles Area  : 23070   United Kingdom: 36199
##  San Francisco Bay Area    : 22643   United States :430470
##  Washington D.C. Metro Area: 19744
##  Greater Chicago Area      : 18521
##  Greater Boston Area       : 16898
##  (Other)                   :337440
##                   DESTINATION_REGION
##  Greater New York City Area: 38088
##  San Francisco Bay Area    : 36707
##  Washington D.C. Metro Area: 25549
##  Greater Los Angeles Area  : 23362
##  London, United Kingdom    : 20136
##  Greater Boston Area       : 17909
##  (Other)                   :313565
```

```r
#  sapply(migr, class)   # get class of all columns
```

- **INSIGHTs**:
  - Data contains 347 origin regions and only 282 destinations
  - All Linkedin members (in data) have some tertiary education degree, ~ 50% are Entry level
  - Linkedin members (in data) are distributed in 14 sectors

```r
both <- left_join(demog,migr, by="NEW_MEM_ID")
```

Merge the 2 tables

2.b Frequencies and Proportions

I'm interested in studying members distribution across categorical variables according to origin country

Percentages and Proportions of *HIGHEST DEGREE* across countries of origin

```
# Single variable
country <- table(both$SOURCE_COUNTRY)
# Proportions for a single variable table
prop.table(country)

# Cross table by two variables
xcountry <- xtabs(~ HIGHEST_DEGREE_OBTAINED +SOURCE_COUNTRY, both)
# xcountry
addmargins(xcountry)

# Proportions in Cross Table
prop.table(xcountry)              # proportion to total
prop.table(xcountry, margin = 1)   # proportion to row sum (DEGREE)
prop.table(xcountry, margin = 2)   # proportion to column sum (ORIGIN COUNTRY)

# Stratified Table
## 3rd variable as stratified variable
xcountry2 <- xtabs(~ HIGHEST_DEGREE_OBTAINED +SENIORITY +SOURCE_COUNTRY, both)
xcountry2
## flat table
ftable(xcountry2)
```

Proportions of HIGHEST DEGREE/Seniority/Sector/Position against Country of origin with *Dplyr*

```
#   Prop of members in each DEGREE to SUM of Country of origin
freq_OrigDegree <- both %>%
  group_by(both[,7],both[,2]) %>%
  summarise (n = n()) %>%
  mutate(freq = n / sum(n)) %>%
  mutate(rel.freq = paste0(round(100 * n/sum(n), 2), "%"))
```

```
## `summarise()` has grouped output by 'both[, 7]'. You can override using the
## `.groups` argument.
```

```
freq_OrigDegree  #
```

```
## # A tibble: 12 x 5
## # Groups:   both[, 7] [3]
##    `both[, 7]`    `both[, 2]`      n   freq rel.freq
##    <fct>          <fct>        <int>  <dbl> <chr>
##  1 Australia      associate      255 0.0286 2.86%
##  2 Australia      bachelor      5632 0.633  63.27%
##  3 Australia      doctor         611 0.0686 6.86%
##  4 Australia      master        2404 0.270  27.01%
##  5 United Kingdom associate     1312 0.0358 3.58%
##  6 United Kingdom bachelor     22107 0.604  60.38%
##  7 United Kingdom doctor        3533 0.0965 9.65%
##  8 United Kingdom master        9663 0.264  26.39%
##  9 United States  associate    79505 0.185  18.5%
## 10 United States  bachelor    225213 0.524  52.4%
## 11 United States  doctor       36358 0.0846 8.46%
## 12 United States  master       88723 0.206  20.64%
```

```r
freq_OrigSniority <- both %>%
  group_by(both[,7],both[,3]) %>%
  summarise (n = n()) %>%
  mutate(freq = n / sum(n)) %>%
  mutate(rel.freq = paste0(round(100 * n/sum(n), 2), "%"))
```

```
## `summarise()` has grouped output by 'both[, 7]'. You can override using the
## `.groups` argument.
```

```r
freq_OrigSniority  # % remarkably similar in terms of Seniority  across countries of ORIGIN
```

```
## # A tibble: 31 x 5
## # Groups:   both[, 7] [3]
##    `both[, 7]` `both[, 3]`      n     freq rel.freq
##    <fct>       <fct>        <int>    <dbl> <chr>
##  1 Australia   CXO            119 0.0134   1.34%
##  2 Australia   Director       323 0.0363   3.63%
##  3 Australia   Entry         3542 0.398    39.79%
##  4 Australia   Manager       1150 0.129    12.92%
##  5 Australia   Owner           80 0.00899  0.9%
##  6 Australia   Partner         41 0.00461  0.46%
##  7 Australia   Senior        3331 0.374    37.42%
##  8 Australia   Training       154 0.0173   1.73%
##  9 Australia   Unpaid           1 0.000112 0.01%
## 10 Australia   VP             161 0.0181   1.81%
## # i 21 more rows
```

```r
freq_OrigSector <- both %>%
  group_by(both[,7],both[,4]) %>%
  summarise (n = n()) %>%
  mutate(freq = n / sum(n)) %>%
  mutate(rel.freq = paste0(round(100 * n/sum(n), 2), "%"))
```

```
## `summarise()` has grouped output by 'both[, 7]'. You can override using the
## `.groups` argument.
```

```r
freq_OrigSector  # % remarkably similar in terms of sector across countries
```

```
## # A tibble: 42 x 5
## # Groups:   both[, 7] [3]
##    `both[, 7]` `both[, 4]`                            n   freq rel.freq
##    <fct>       <fct>                              <int>  <dbl> <chr>
##  1 Australia   Aero/Auto/Transport                  357 0.0401 4.01%
##  2 Australia   Architecture & Engineering           805 0.0904 9.04%
##  3 Australia   Financial Services & Insurance       926 0.104  10.4%
##  4 Australia   Government/Education/Non-profit     1716 0.193  19.28%
##  5 Australia   Healthcare & Pharmaceutical          723 0.0812 8.12%
##  6 Australia   Manufacturing/Industrial             372 0.0418 4.18%
##  7 Australia   Media & Entertainment                506 0.0568 5.68%
##  8 Australia   Oil & Energy                         251 0.0282 2.82%
##  9 Australia   Professional Services               1481 0.166  16.64%
## 10 Australia   Retail & Consumer Products           504 0.0566 5.66%
## # i 32 more rows
```

```r
freq_OrigPosition <- both %>%
  group_by(both[,7],both[,5]) %>%
```

```r
  summarise (n = n()) %>%
  mutate(freq = n / sum(n)) %>%
  mutate(rel.freq = paste0(round(100 * n/sum(n), 2), "%"))
```

```
## `summarise()` has grouped output by 'both[, 7]'. You can override using the
## `.groups` argument.
```

```r
freq_OrigPosition  # % remarkably similar in terms of position across countries
```

```
## # A tibble: 78 x 5
## # Groups:   both[, 7] [3]
##    `both[, 7]` `both[, 5]`                       n   freq rel.freq
##    <fct>       <fct>                         <int>  <dbl> <chr>
##  1 Australia   Accounting                      208 0.0234 2.34%
##  2 Australia   Administrative                  162 0.0182 1.82%
##  3 Australia   Arts and Design                 293 0.0329 3.29%
##  4 Australia   Business Development            663 0.0745 7.45%
##  5 Australia   Community and Social Services   439 0.0493 4.93%
##  6 Australia   Consulting                      247 0.0277 2.77%
##  7 Australia   Education                       521 0.0585 5.85%
##  8 Australia   Engineering                     830 0.0932 9.32%
##  9 Australia   Entrepreneurship                112 0.0126 1.26%
## 10 Australia   Finance                         508 0.0571 5.71%
## # i 68 more rows
```

- **INSIGHTs**:
  - US has a significantly higher # of Associates leaving (18% vs 3% and 4%)
  - Proportions seem remarkably similar in terms of Seniority / Sector / Position across countries of ORIGIN
  - At the country level there are no big differences… probably makes more sense looking at city or internally
  - Wonder if this is a subset of real Linkedin members or if there are particular similarities in the English-speaking countries

Percentages and Proportions - Seniority/Sector/Position against Country of DESTINATION- with *Dplyr*

I do the same analysis but looking at DESTINATION * Very similar results as per Origin

```r
# prop DEGREE by country orf destin
freq_DestDegree <- both %>%
  group_by(both[,9],both[,2]) %>%
  summarise (n = n()) %>%
  mutate(freq = n / sum(n)) %>%
  mutate(rel.freq = paste0(round(100 * n/sum(n), 2), "%"))
freq_DestDegree  # US has a significantly higher # of Associates leaving (18% vs 3% and 4%)

# prop SENIORITY by country orf destin
freq_DestSniority <- both %>%
  group_by(both[,9],both[,3]) %>%
  summarise (n = n()) %>%
  mutate(freq = n / sum(n)) %>%
  mutate(rel.freq = paste0(round(100 * n/sum(n), 2), "%"))
freq_DestSniority  # % remarkably similar in terms of Seniority across countries

# prop SECTOR by country orf destin
```

```r
freq_DestSector <- both %>%
  group_by(both[,9],both[,4]) %>%
  summarise (n = n()) %>%
  mutate(freq = n / sum(n)) %>%
  mutate(rel.freq = paste0(round(100 * n/sum(n), 2), "%"))
freq_DestSector  # % remarkably similar in terms of sector across countries

# prop POSITION by country orf destin
freq_DestPosition <- both %>%
  group_by(both[,9],both[,5]) %>%
  summarise (n = n()) %>%
  mutate(freq = n / sum(n)) %>%
  mutate(rel.freq = paste0(round(100 * n/sum(n), 2), "%"))
freq_DestPosition  # % remarkably similar in terms of position across countries

# 3-Way Frequency Table
# mytable <- table(both[,4],both[,2], both[,3])
# ftable(mytable)
```

3 DATA EXPLORATION BY CITY

```r
# create origin table
origin <- both %>% select(id=NEW_MEM_ID, degree=HIGHEST_DEGREE_OBTAINED, seniority=SENIORITY, sector=EMI

# create destination table
destination <- both %>% select(id=NEW_MEM_ID, degree=HIGHEST_DEGREE_OBTAINED, seniority=SENIORITY, secto
```

interim manipulation

3.1 Top 10 cities (US)

```r
# Aggregate N flow (OUT) by City
library (knitr)
library(kableExtra)
aggreOrig <- origin  %>%
  group_by(cityO) %>%
  summarize(NumOutflow= n())  %>%
  mutate(freq = NumOutflow / sum(NumOutflow)) %>%
  mutate(rel.freq = as.numeric(paste0(round(100 * NumOutflow/sum(NumOutflow), 3))))  %>%
  arrange(desc(NumOutflow))

# Top 10 ORIGIN cities
aggreOrig_short <- aggreOrig[1:10,]
kable(aggreOrig_short, #format = "html",
      caption = "Ranking of cities by Origin") %>%  kable_styling(bootstrap_options = c("striped", "hove
```

```r
# create destination table
destination <- both %>% select(id=NEW_MEM_ID, degree=HIGHEST_DEGREE_OBTAINED, seniority=SENIORITY, secto


# Aggregate N flow (IN) by City
 library (knitr)
```

Table 1: Ranking of cities by Origin

cityO	NumOutflow	freq	rel.freq
Greater New York City Area	37000	0.0778430	7.784
Greater Los Angeles Area	23070	0.0485361	4.854
San Francisco Bay Area	22643	0.0476378	4.764
Washington D.C. Metro Area	19744	0.0415387	4.154
Greater Chicago Area	18521	0.0389657	3.897
Greater Boston Area	16898	0.0355511	3.555
Dallas/Fort Worth Area	11592	0.0243880	2.439
Greater Philadelphia Area	11407	0.0239988	2.400
Greater Atlanta Area	11092	0.0233361	2.334
London, United Kingdom	10249	0.0215625	2.156

Table 2: Ranking of cities by popular destination

cityD	NumInflow	freq	rel.freq
Greater New York City Area	38088	0.0801320	8.013
San Francisco Bay Area	36707	0.0772265	7.723
Washington D.C. Metro Area	25549	0.0537516	5.375
Greater Los Angeles Area	23362	0.0491505	4.915
London, United Kingdom	20136	0.0423634	4.236
Greater Boston Area	17909	0.0376781	3.768
Greater Chicago Area	16944	0.0356479	3.565
Dallas/Fort Worth Area	16157	0.0339921	3.399
Greater Seattle Area	15553	0.0327214	3.272
Greater Atlanta Area	14242	0.0299632	2.996

```r
library(kableExtra)
aggreDest <- destination  %>%
  group_by(cityD) %>%
  summarize(NumInflow= n())  %>%
  mutate(freq = NumInflow / sum(NumInflow)) %>%
  mutate(rel.freq = as.numeric(paste0(round(100 * NumInflow/sum(NumInflow), 3))))  %>%
  arrange(desc(NumInflow))

# Top 10 DESTINATION cities
aggreDest_short <- aggreDest[1:10,]
kable(aggreDest_short, #format = "html",
      caption = "Ranking of cities by popular destination") %>% kable_styling(bootstrap_options = c("st
```

- **INSIGHTs**:
  - Intristingly, London is # 5 Origin but # 10 Destination
  - 9/10 top DESTINATION are the same as top ORIGIN which suggest there is mobility, but not necessarily the top destination are places where people stay
  - this can be explained by the American way of moving to and from the city of college
  - *those where all american !!!*

Table 3: Ranking of cities by Origin

cityO	NumOutflow	freq	rel.freq
London, United Kingdom	10249	0.2799126	27.991
Manchester, United Kingdom	1170	0.0319541	3.195
Reading, United Kingdom	1002	0.0273658	2.737
Twickenham, United Kingdom	990	0.0270381	2.704
Oxford, United Kingdom	978	0.0267104	2.671
Birmingham, United Kingdom	836	0.0228322	2.283
Guildford, United Kingdom	828	0.0226137	2.261
Kingston upon Thames, United Kingdom	788	0.0215212	2.152
Coventry, United Kingdom	695	0.0189813	1.898
Cambridge, United Kingdom	668	0.0182439	1.824

3.2 Top 10 cities (UK)

```
# Aggregate N flow (OUT) by City
library (knitr)
library(kableExtra)

# subset origin
originUK <- subset (origin , countryO == "United Kingdom")

aggreOrigUK <- originUK  %>%
  group_by(cityO) %>%
  summarize(NumOutflow= n())  %>%
  mutate(freq = NumOutflow / sum(NumOutflow)) %>%
  mutate(rel.freq = as.numeric(paste0(round(100 * NumOutflow/sum(NumOutflow), 3))))  %>%
  arrange(desc(NumOutflow))  #%>% left_join(origin, by="cityO")

# Top 10 ORIGIN cities
aggreOrig_shortUK <- aggreOrigUK[1:10,]
kable(aggreOrig_shortUK, #format = "html",
      caption = "Ranking of cities by Origin") %>%  kable_styling(bootstrap_options = c("striped", "hov
```

```
# =====================================================#

# subset destination
destinationUK <- subset (destination , countryD == "United Kingdom")


# Aggregate N flow (IN) by City
 library (knitr)
library(kableExtra)
aggreDestUK <- destinationUK  %>%
  group_by(cityD) %>%
  summarize(NumInflow= n())  %>%
  mutate(freq = NumInflow / sum(NumInflow)) %>%
  mutate(rel.freq = as.numeric(paste0(round(100 * NumInflow/sum(NumInflow), 3))))  %>%
  arrange(desc(NumInflow))

# Top 10 DESTINATION cities
aggreDest_shortUK <- aggreDestUK[1:10,]
```

Table 4: Ranking of cities by popular destination

cityD	NumInflow	freq	rel.freq
London, United Kingdom	20136	0.5562585	55.626
Manchester, United Kingdom	1859	0.0513550	5.136
Birmingham, United Kingdom	949	0.0262162	2.622
Edinburgh, United Kingdom	803	0.0221829	2.218
Bristol, United Kingdom	754	0.0208293	2.083
Reading, United Kingdom	754	0.0208293	2.083
Cambridge, United Kingdom	719	0.0198624	1.986
Leeds, United Kingdom	695	0.0191994	1.920
Glasgow, United Kingdom	682	0.0188403	1.884
Oxford, United Kingdom	554	0.0153043	1.530

```
kable(aggreDest_shortUK, #format = "html",
      caption = "Ranking of cities by popular destination") %>% kable_styling(bootstrap_options = c("st
```

- **INSIGHTs**:
  - Contrary to widespread mobility in US, London is origin of 28% of migrants and the Destination for 55% of them

3.3 Top 10 cities (Austr)

```
# Aggregate N flow (OUT) by City
library (knitr)
library(kableExtra)

# subset origin
originAustr <- subset (origin , countryO == "Australia")

aggreOrigAustr <- originAustr  %>%
  group_by(cityO) %>%
  summarize(NumOutflow= n())  %>%
  mutate(freq = NumOutflow / sum(NumOutflow)) %>%
  mutate(rel.freq = as.numeric(paste0(round(100 * NumOutflow/sum(NumOutflow), 3))))  %>%
  arrange(desc(NumOutflow))  #%>% left_join(origin, by="cityO")

# Top 10 ORIGIN cities
aggreOrig_shortAustr <- aggreOrigAustr[1:10,]
kable(aggreOrig_shortAustr, #format = "html",
      caption = "Ranking of cities by Origin") %>%  kable_styling(bootstrap_options = c("striped", "hove
```

```
# ======================================================#

# subset destination
destinationAustr <- subset (destination , countryD == "Australia")


# Aggregate N flow (IN) by City
 library (knitr)
library(kableExtra)
aggreDestAustr <- destinationAustr  %>%
```

Table 5: Ranking of cities by Origin

cityO	NumOutflow	freq	rel.freq
Sydney Area, Australia	3209	0.3604808	36.048
Brisbane Area, Australia	1995	0.2241069	22.411
Perth Area, Australia	1014	0.1139070	11.391
Adelaide Area, Australia	611	0.0686363	6.864
Canberra Area, Australia	556	0.0624579	6.246
Queensland, Australia	468	0.0525725	5.257
New South Wales, Australia	357	0.0401033	4.010
Newcastle Area, Australia	216	0.0242642	2.426
Western Australia, Australia	103	0.0115704	1.157
Toowoomba Area, Australia	74	0.0083127	0.831

Table 6: Ranking of cities by popular destination

cityD	NumInflow	freq	rel.freq
Sydney Area, Australia	3885	0.4492888	44.929
Brisbane Area, Australia	2046	0.2366139	23.661
Canberra Area, Australia	674	0.0779461	7.795
Perth Area, Australia	532	0.0615242	6.152
Queensland, Australia	452	0.0522725	5.227
New South Wales, Australia	393	0.0454493	4.545
Adelaide Area, Australia	306	0.0353880	3.539
Newcastle Area, Australia	180	0.0208165	2.082
Western Australia, Australia	110	0.0127212	1.272
Toowoomba Area, Australia	69	0.0079796	0.798

```
  group_by(cityD) %>%
  summarize(NumInflow= n())  %>%
  mutate(freq = NumInflow / sum(NumInflow)) %>%
  mutate(rel.freq = as.numeric(paste0(round(100 * NumInflow/sum(NumInflow), 3))))  %>%
  arrange(desc(NumInflow))

# Top 10 DESTINATION cities
aggreDest_shortAustr <- aggreDestAustr[1:10,]
kable(aggreDest_shortAustr, #format = "html",
      caption = "Ranking of cities by popular destination") %>% kable_styling(bootstrap_options = c("st
```

- **INSIGHTs**:
  - Similar to UK, in Australiam Sydney is the origin of 36% of migrants and the Destination for 50% of them

3.4 Plots of top cities

```
# Adding some variables for plots
aggreByCity <- full_join(aggreDest,aggreOrig, by = c("cityD" = "cityO"))
aggreByCity[c("NumInflow", "NumOutflow")][is.na(aggreByCity[c("NumInflow", "NumOutflow")])] <- 0

aggreByCity <-  aggreByCity %>%
  select(-freq.x,-rel.freq.x, -freq.y, -rel.freq.y) %>%  # get rid of meeaningless
```

```r
  mutate (NetFlow= NumInflow -NumOutflow) %>% # Net
  mutate (NegOutFlow= -(NumOutflow)) %>% # neg sign
  mutate (Sign = ifelse(NetFlow > 0, "Positive", "Negative")) %>%
  mutate (colour= ifelse(NetFlow > 0, "positive", "negative")) %>%  mutate (city_copy = cityD)  %>%
  separate(city_copy, into = c("city_only", "metro area"), sep = ",")

summary(aggreByCity)
```

JOIN the AGGREGATE by CITY to have Net flows in the same table (by City)

```r
# ====================== INTERIM ======================= #
names(aggreByCity)[1]<-"city"
names(migr)[4]<-"city"
# city_country <-full_join(aggreByCity, migr, by = c("city", "SOURCE_REGION")) %>%  # #select(city,coun

city_country <-full_join(aggreByCity, migr, by = "city") %>%
  select(city, country=DESTINATION_COUNTRY) %>%
  distinct () %>% # need the dup flag
  mutate(dupli = ifelse((city =="Greater New York City Area"|city =="San Francisco Bay Area" |city =="Wa
  city =="Greater Los Angeles Area"|city =="Greater Boston Area"|city =="Greater Chicago Area" |
  city =="Dallas/Fort Worth Area" |city =="Greater Seattle Area" |city =="San Francisco Bay Area") & co

  mutate(dupli2 = ifelse((city =="London, United Kingdom") & country!="United kindom", "dup", "")) %>% 

  mutate(dupli3 = ifelse((city =="Sydney Area, Australia") & country!="Australia", "dup", "")) %>% # ne

  mutate(dupli4 = ifelse((city =="Perth Area, Australia") & country!="Australia", "dup", "")) %>% # nee

  mutate(dupli5 = ifelse((city =="Miami/Fort Lauderdale Area") & country!="United States", "dup", "")) 

  mutate(dupli6 = ifelse((city =="Brisbane Area, Australia") & country!="Australia", "dup", ""))


city_country <- subset(city_country, city_country$dupli!="dup" & city_country$dupli2!="dup" & city_coun


newRow <- data.frame(city ="London, United Kingdom", country ="United Kingdom" )

city_country <- rbind(city_country,newRow)
#city_country <- rbind(city_country, c("London, United Kingdom", "United kindom"))

names(aggreByCity)[1]<-"cityD"
# ===================================================== #
```

interim

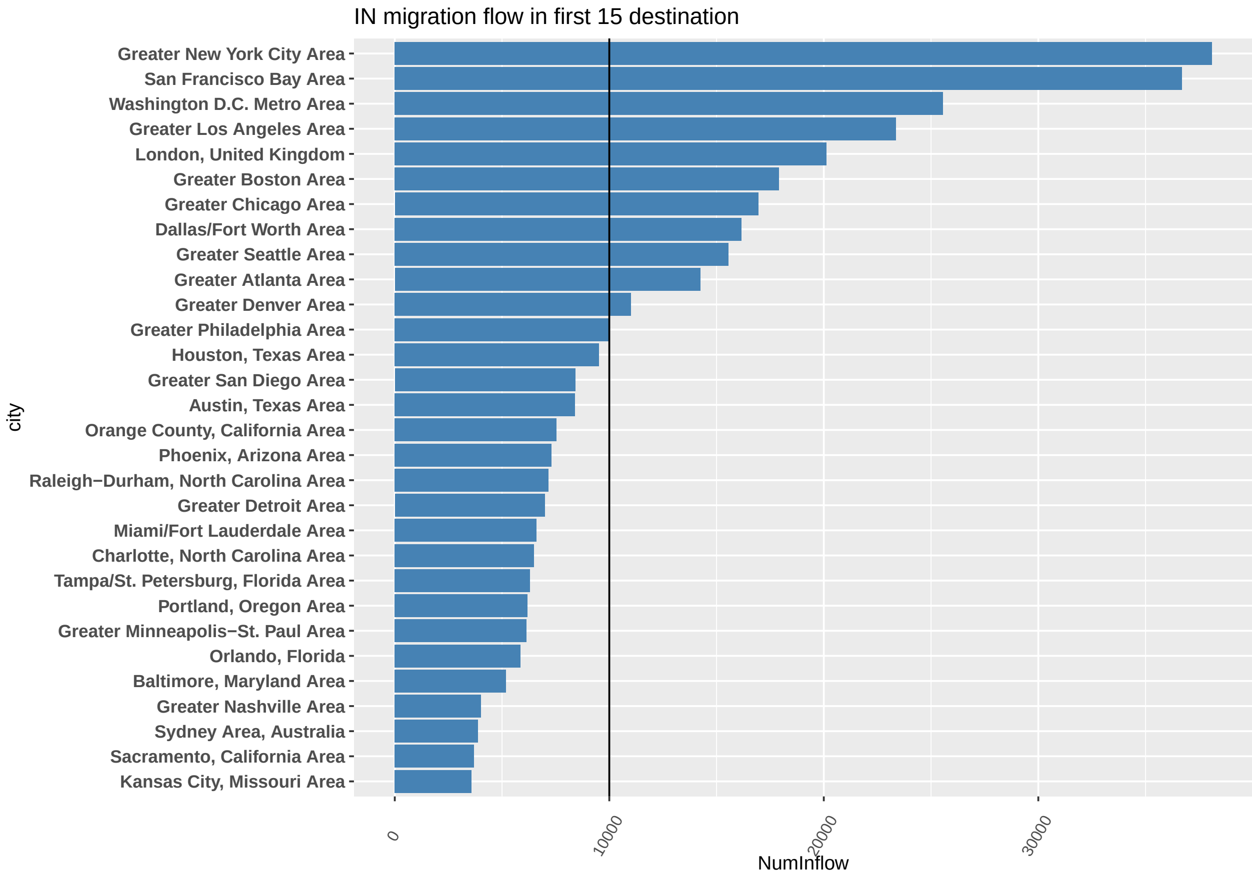
Major 30 (World - mostly US) cities TO people are migrating

```r
names(aggreByCity)[1]<-"city"

# 1) In  Flow in Top DESTINATION
Top_in <- aggreByCity %>% top_n(30, NumInflow)
  Top_in$city = with(Top_in, reorder(city,NumInflow)) # reorder Levels by Var
```

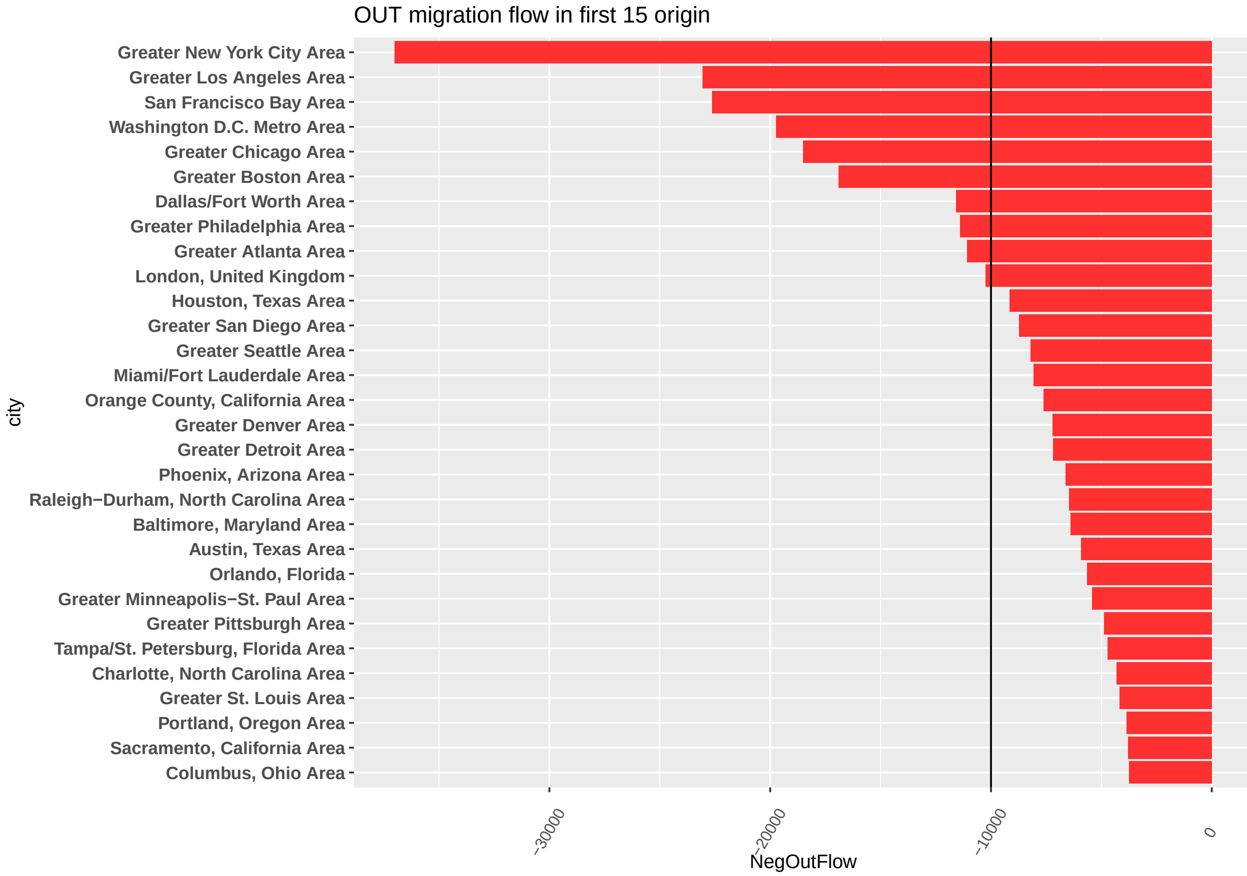
```r
Top_in <- ggplot(data = Top_in,aes(city, NumInflow)) +
  geom_bar(stat = "identity", position="identity", fill = "steelblue") +
  geom_hline(yintercept=10000, color = "black", size=0.5) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold"
  labs(title="IN migration flow in first 15 destination")
```

```
## Warning: Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use `linewidth` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```

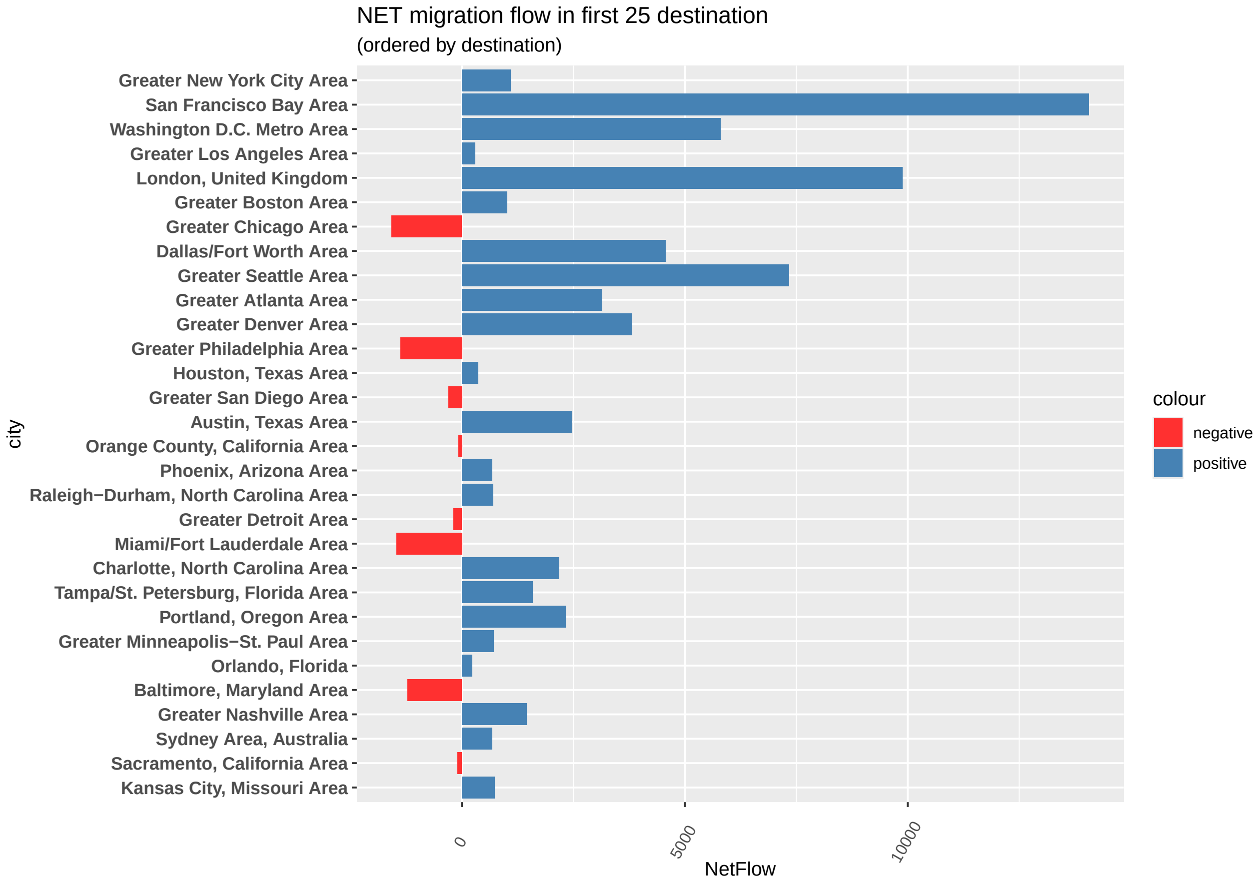
```r
Top_in + coord_flip()
```



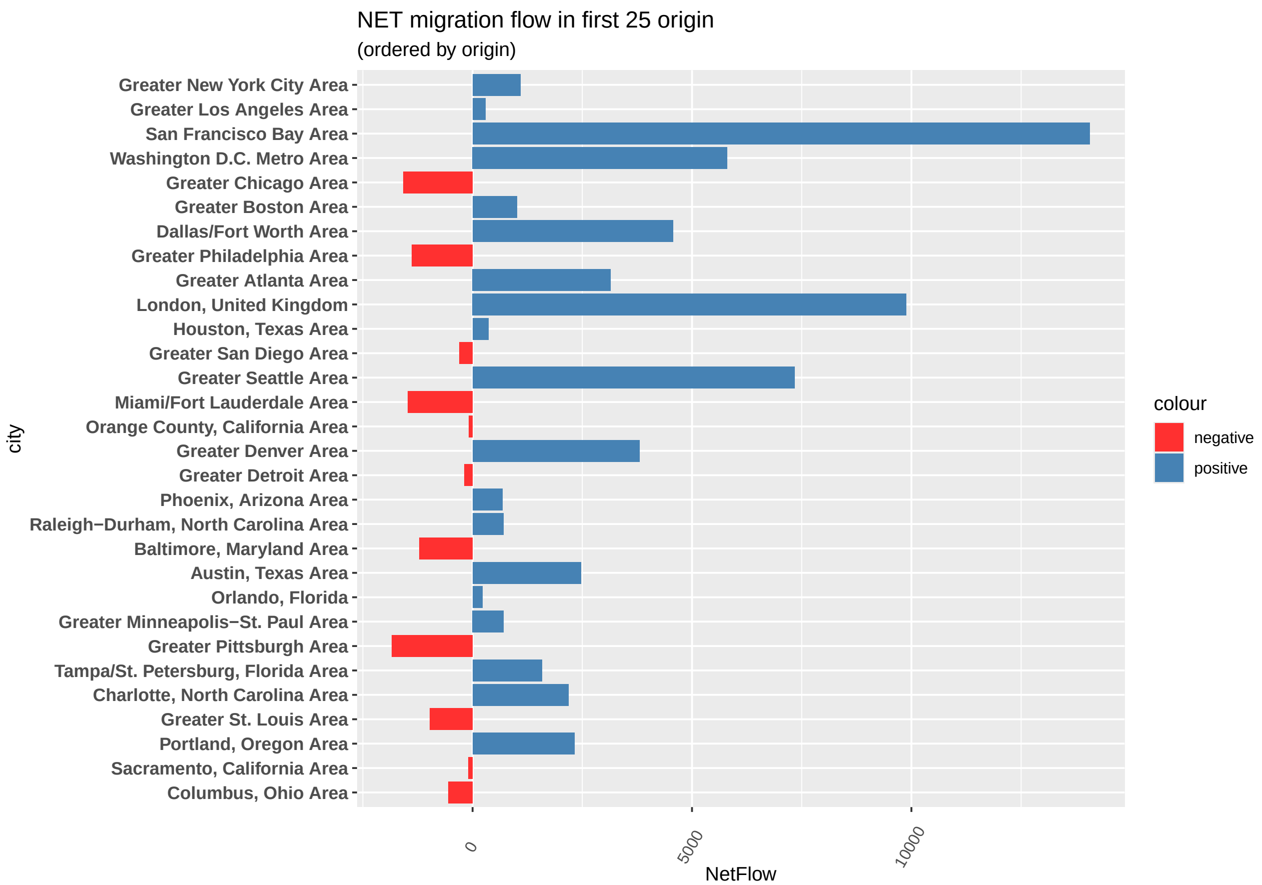

```r
# 2) Out  Flow in Top ORIGIN
Top_out <- aggreByCity %>% top_n(30, NumOutflow)
  Top_out$city = with(Top_out, reorder(city,NumOutflow)) # reorder Levels by Var

Top_out <- ggplot(data = Top_out,aes(city, NegOutFlow)) +
  geom_bar(stat = "identity", position="identity", fill = "firebrick1") +
   geom_hline(yintercept=-10000, color = "black", size=0.5) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold"
  labs(title="OUT migration flow in first 15 origin")

Top_out + coord_flip()
```




```r
# plot side by side
# library(gridExtra)
# grid.arrange(in_flip, out_flip, ncol=2)

# 3.a)  NET flow in Top  DESTINATION
Top_net <- aggreByCity %>% top_n(30, NumInflow)
  Top_net$city = with(Top_net, reorder(city,NumInflow)) # reorder Levels by Var

Top_net <- ggplot(data = Top_net,aes(city, NetFlow)) +
  geom_bar(stat = "identity", position="identity",aes(fill = colour)) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold"
  scale_fill_manual(values=c(positive="steelblue",negative="firebrick1")) +
  labs(title="NET migration flow in first 25 destination", subtitle="(ordered by destination)")

Top_net + coord_flip()
```




```
# 3.b)  NET flow in Top  ORIGIN
Top_net <- aggreByCity %>% top_n(30, NumOutflow)
  Top_net$city = with(Top_net, reorder(city,NumOutflow)) # reorder Levels by Var

Top_net <- ggplot(data = Top_net,aes(city, NetFlow)) +
  geom_bar(stat = "identity", position="identity",aes(fill = colour)) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold"
  scale_fill_manual(values=c(positive="steelblue",negative="firebrick1")) +
  labs(title="NET migration flow in first 25 origin", subtitle="(ordered by origin)")
Top_net + coord_flip()
```



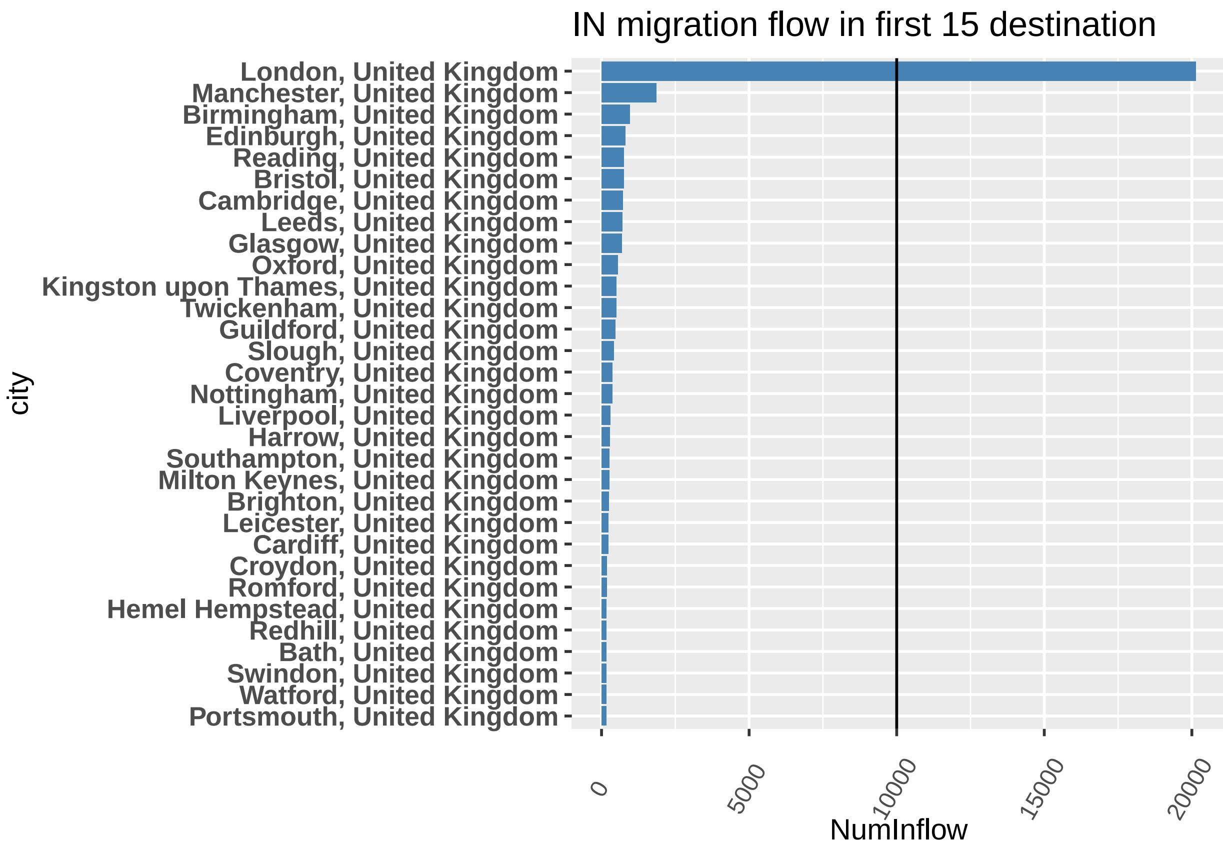

```
# all american
# lots of leaving in 2016 - especially in NY
```

```
# add country to aggreByCity
aggreByCity2 <- left_join(aggreByCity,city_country,by = "city")

# x[c("a", "b")][is.na(x[c("a", "b")])] <- 0
aggreByCity2[c("NumInflow", "NumOutflow")][is.na(aggreByCity2[c("NumInflow", "NumOutflow")])] <- 0
```

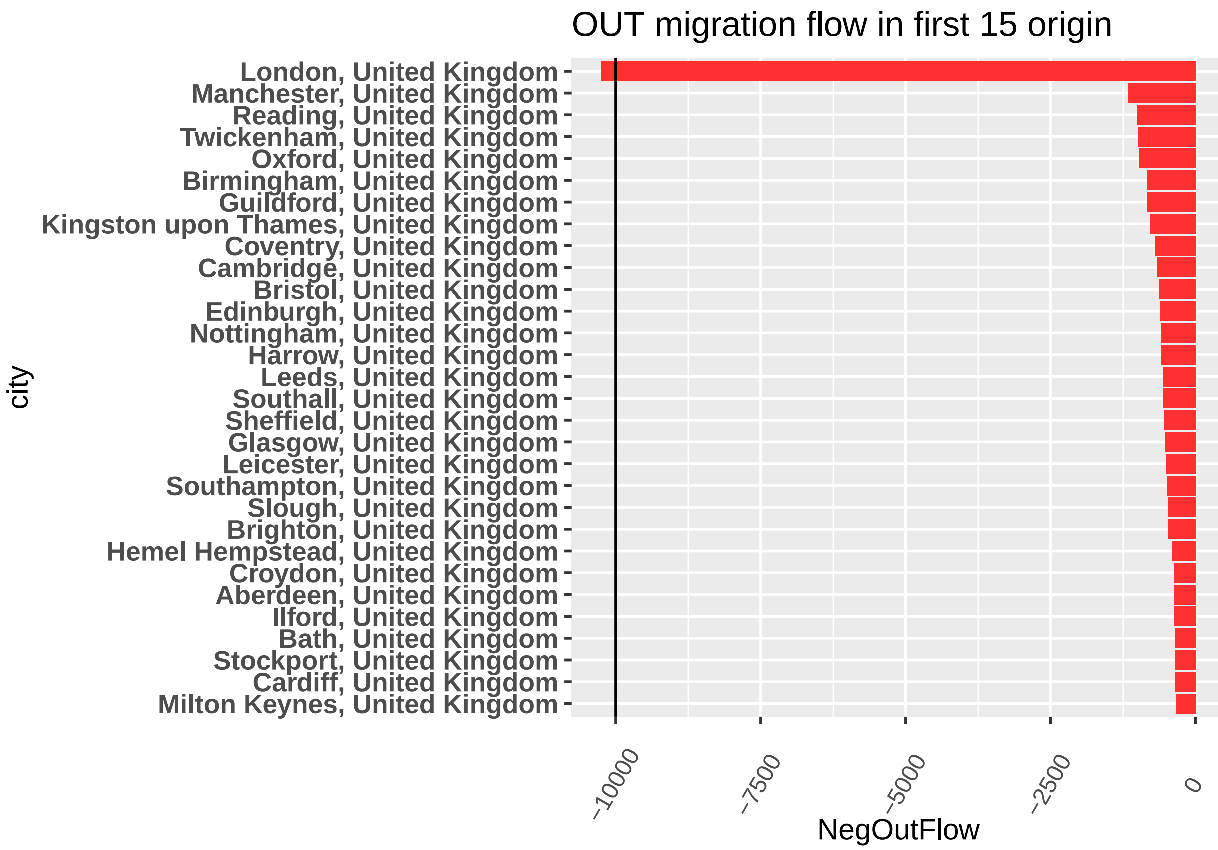
Major 20 (UK) cities TO / FROM / NET migration

```
# 1) In  Flow in Top DESTINATION

aggreByCityUK <- aggreByCity2 %>%
  filter (country == "United Kingdom")

Top_inUK <- aggreByCityUK %>%
  top_n(30, NumInflow)

Top_inUK$city = with(Top_inUK, reorder(city,NumInflow)) # reorder Levels by Var

Top_inUK <- ggplot(data = Top_inUK,aes(city, NumInflow)) +
  geom_bar(stat = "identity", position="identity", fill = "steelblue") +
  geom_hline(yintercept=10000, color = "black", size=0.5) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold"
  labs(title="IN migration flow in first 15 destination")
```

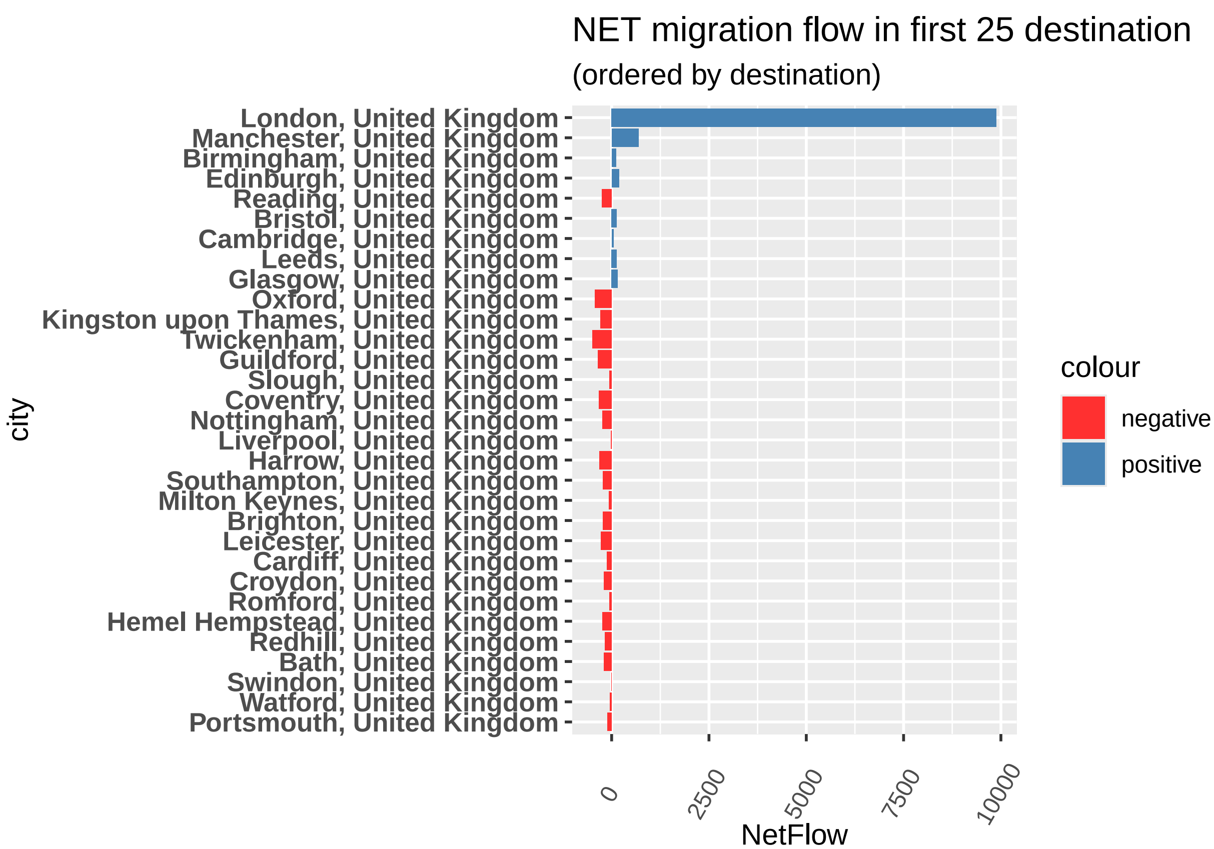
```r
Top_inUK + coord_flip()
```



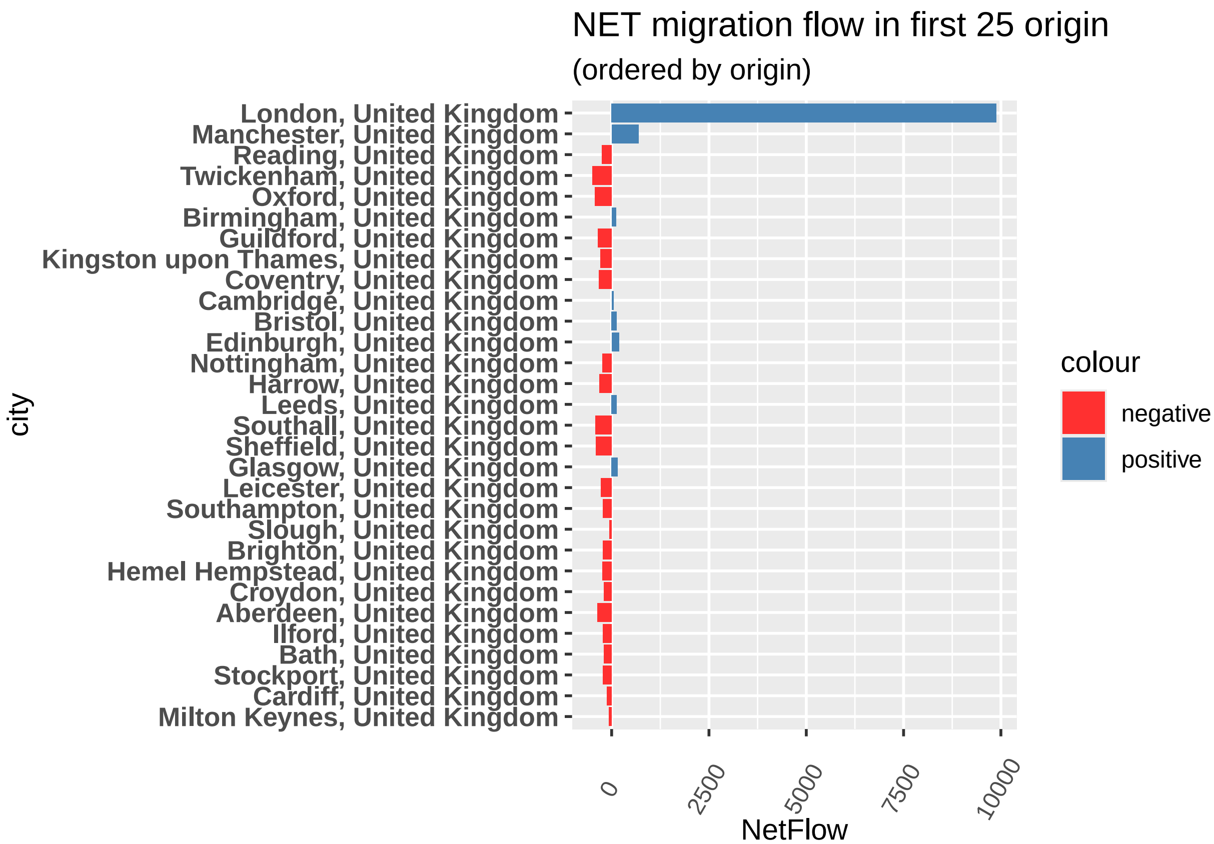

```r
# 2) Out  Flow in Top ORIGIN
Top_outUK <- aggreByCityUK %>%
  filter (country == "United Kingdom") %>% # filter by country = UK
  top_n(30, NumOutflow)
  Top_outUK$city = with(Top_outUK, reorder(city,NumOutflow)) # reorder Levels by Var

Top_outUK <- ggplot(data = Top_outUK,aes(city, NegOutFlow)) +
  geom_bar(stat = "identity", position="identity", fill = "firebrick1") +
   geom_hline(yintercept=-10000, color = "black", size=0.5) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold"
  labs(title="OUT migration flow in first 15 origin")

Top_outUK + coord_flip()
```




```
# 3.a)  NET flow in Top  DESTINATION
Top_netUK <- aggreByCityUK %>%
   filter (country == "United Kingdom") %>% # filter by country = UK
  top_n(30, NumInflow)
  Top_netUK$city = with(Top_netUK, reorder(city,NumInflow)) # reorder Levels by Var

Top_netUK <- ggplot(data = Top_netUK,aes(city, NetFlow)) +
  geom_bar(stat = "identity", position="identity",aes(fill = colour)) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold"
  scale_fill_manual(values=c(positive="steelblue",negative="firebrick1")) +
  labs(title="NET migration flow in first 25 destination", subtitle="(ordered by destination)")
Top_netUK + coord_flip()
```



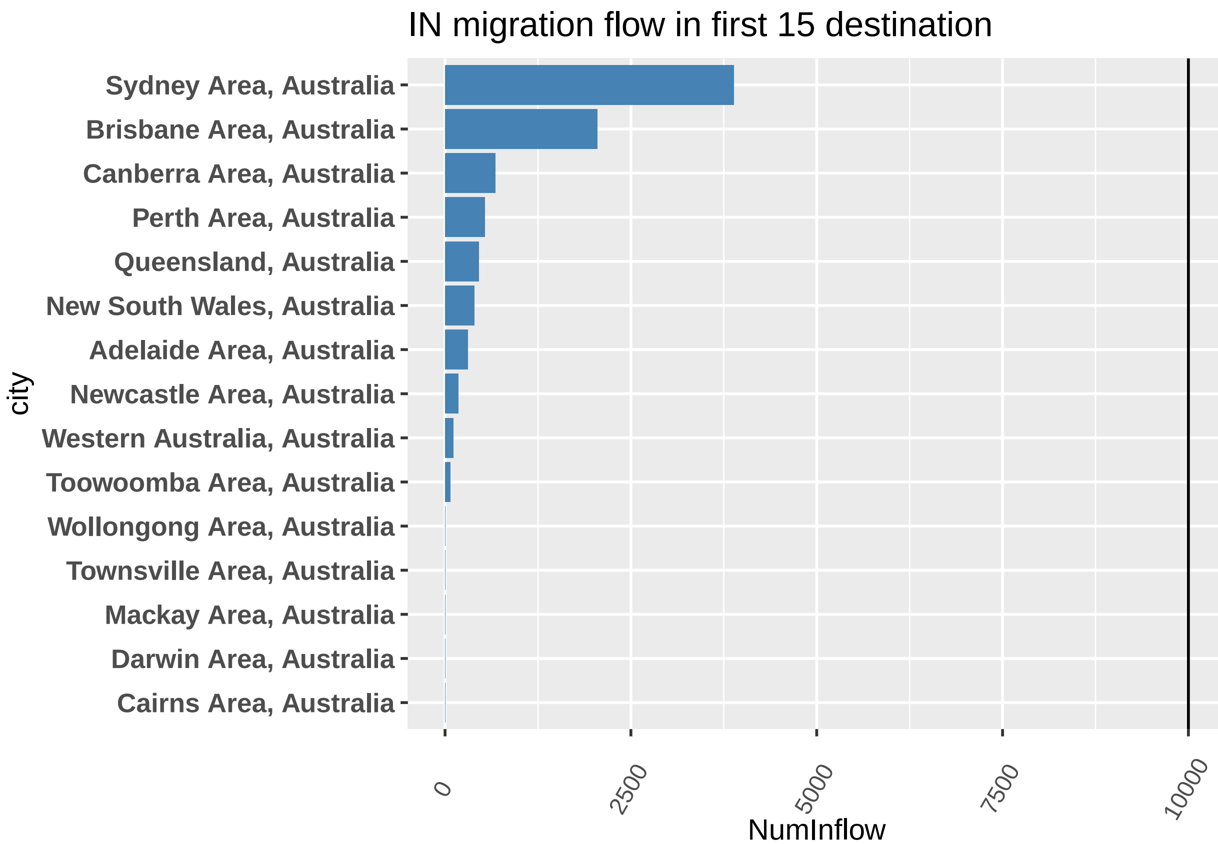

```
# 3.b)  NET flow in Top  ORIGIN
Top_netUK <- aggreByCityUK %>%
   filter (country == "United Kingdom") %>% # filter by country = UK
  top_n(30, NumOutflow)
  Top_netUK$city = with(Top_netUK, reorder(city,NumOutflow)) # reorder Levels by Var

Top_netUK <- ggplot(data = Top_netUK,aes(city, NetFlow)) +
  geom_bar(stat = "identity", position="identity",aes(fill = colour)) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold")
  scale_fill_manual(values=c(positive="steelblue",negative="firebrick1")) +
  labs(title="NET migration flow in first 25 origin", subtitle="(ordered by origin)")
Top_netUK + coord_flip()
```



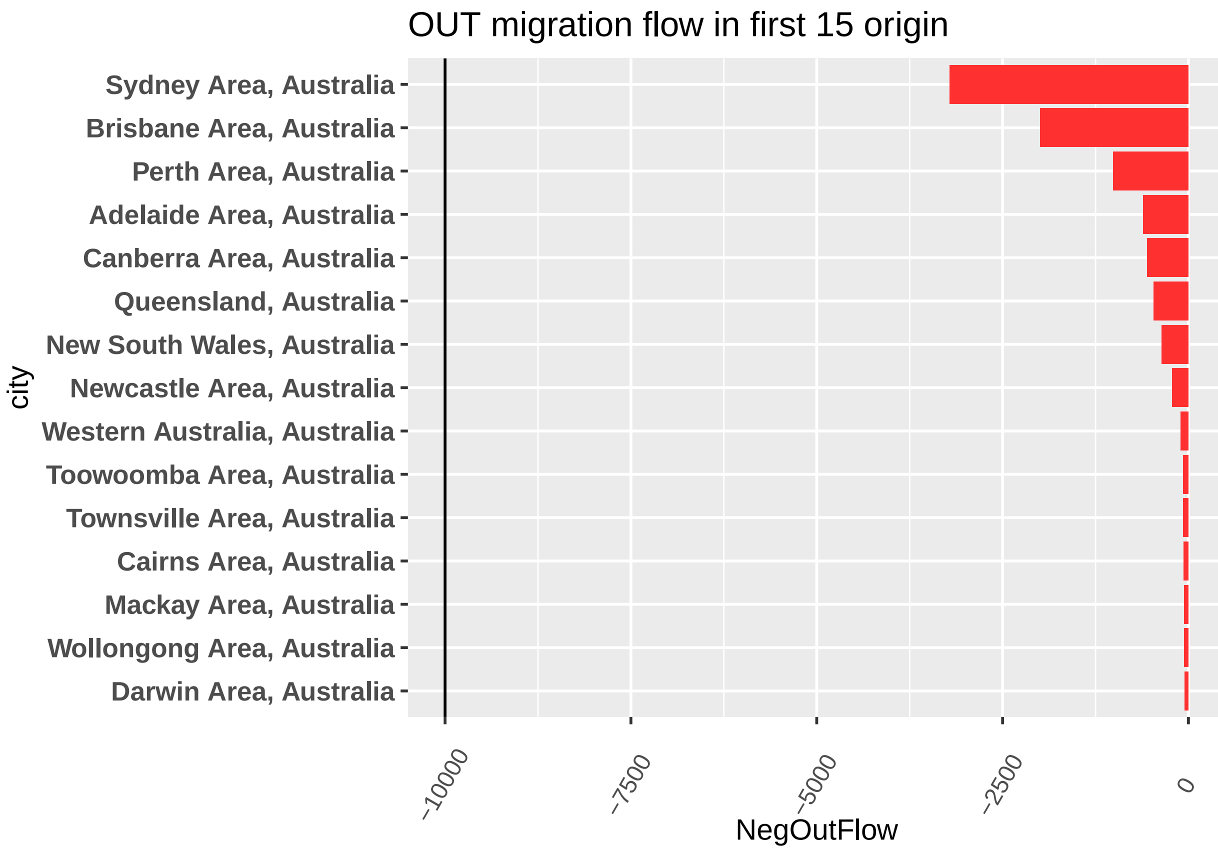
- **INSIGHTs**:
  - Contrary to US, London is a definitive outlier

Major 20 (AUSTRALIA) cities TO / FROM / NET migration

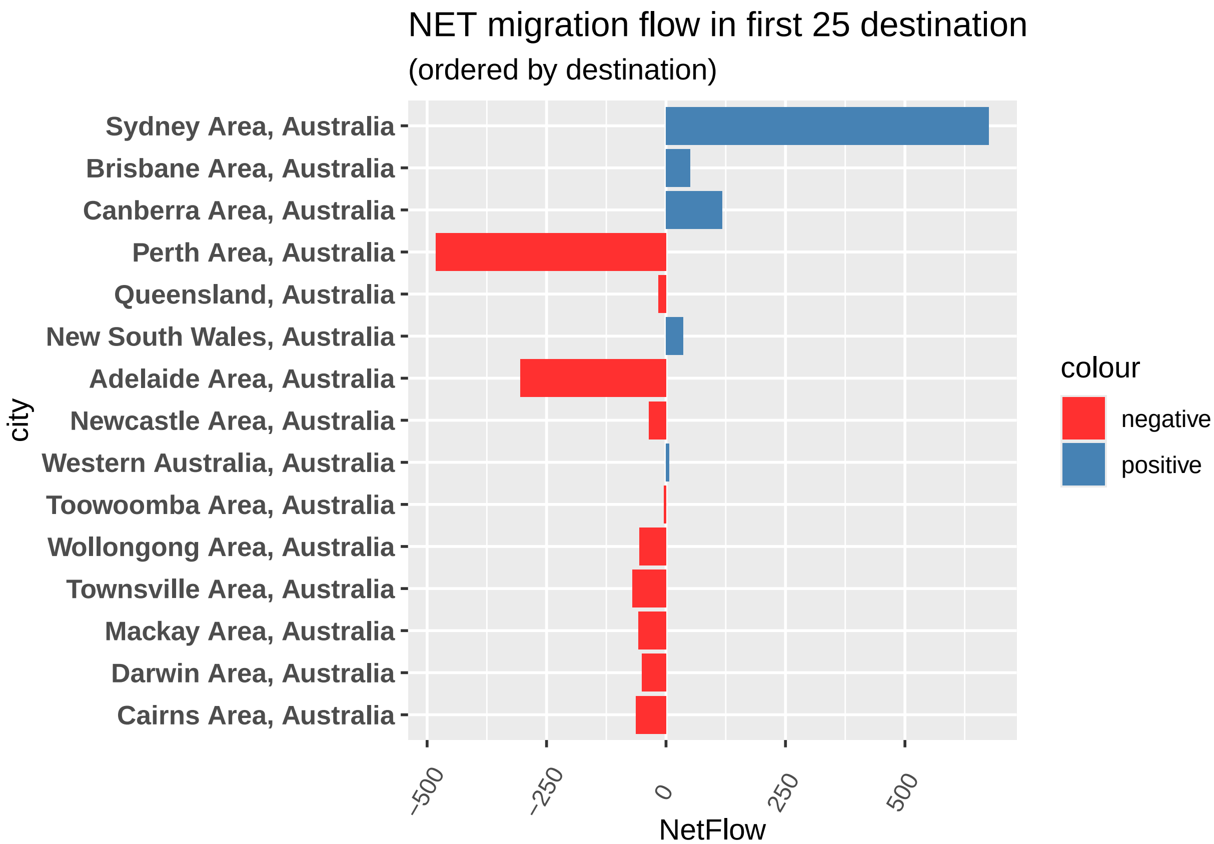
```
# 1) In  Flow in Top DESTINATION

aggreByCityAustr <- aggreByCity2 %>%
  filter (country == "Australia")

Top_inAustr <- aggreByCityAustr %>%
  top_n(30, NumInflow)

Top_inAustr$city = with(Top_inAustr, reorder(city,NumInflow)) # reorder Levels by Var

Top_inAustr <- ggplot(data = Top_inAustr,aes(city, NumInflow)) +
  geom_bar(stat = "identity", position="identity", fill = "steelblue") +
  geom_hline(yintercept=10000, color = "black", size=0.5) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold")
  labs(title="IN migration flow in first 15 destination")


Top_inAustr + coord_flip()
```



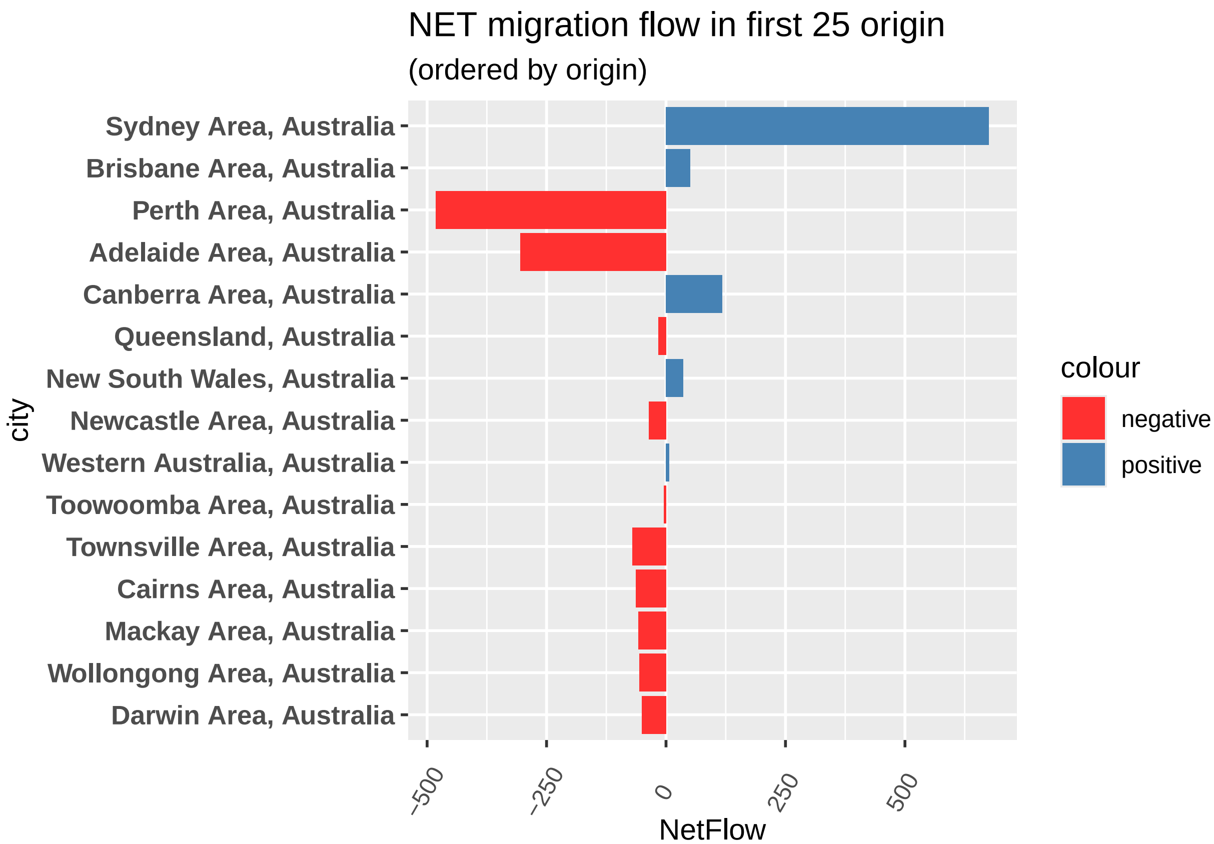

```
# 2) Out  Flow in Top ORIGIN
Top_outAustr <- aggreByCityAustr %>%
  filter (country == "Australia") %>% # filter by country = Austr
  top_n(30, NumOutflow)
  Top_outAustr$city = with(Top_outAustr, reorder(city,NumOutflow)) # reorder Levels by Var

Top_outAustr <- ggplot(data = Top_outAustr,aes(city, NegOutFlow)) +
  geom_bar(stat = "identity", position="identity", fill = "firebrick1") +
   geom_hline(yintercept=-10000, color = "black", size=0.5) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold"
  labs(title="OUT migration flow in first 15 origin")

Top_outAustr + coord_flip()
```




```
# 3.a)  NET flow in Top  DESTINATION
Top_netAustr <- aggreByCityAustr %>%
   filter (country == "Australia") %>% # filter by country = Austr
  top_n(30, NumInflow)
  Top_netAustr$city = with(Top_netAustr, reorder(city,NumInflow)) # reorder Levels by Var

Top_netAustr <- ggplot(data = Top_netAustr,aes(city, NetFlow)) +
  geom_bar(stat = "identity", position="identity",aes(fill = colour)) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold"
  scale_fill_manual(values=c(positive="steelblue",negative="firebrick1")) +
  labs(title="NET migration flow in first 25 destination", subtitle="(ordered by destination)")
Top_netAustr + coord_flip()
```




```r
# 3.b)  NET flow in Top  ORIGIN
Top_netAustr <- aggreByCityAustr %>%
   filter (country == "Australia") %>% # filter by country = Austr
  top_n(30, NumOutflow)
  Top_netAustr$city = with(Top_netAustr, reorder(city,NumOutflow)) # reorder Levels by Var

Top_netAustr <- ggplot(data = Top_netAustr,aes(city, NetFlow)) +
  geom_bar(stat = "identity", position="identity",aes(fill = colour)) +
  theme(axis.text.x = element_text(angle=60, vjust=0.3), axis.text.y = element_text(size=10,face="bold"
  scale_fill_manual(values=c(positive="steelblue",negative="firebrick1")) +
  labs(title="NET migration flow in first 25 origin", subtitle="(ordered by origin)")
Top_netAustr + coord_flip()
```



4 BIVARIATE MEASURES OF ASSOCIATION

4.1 INflow by city vs highest degree

Is there any relation between where they choose to go and the highest degree they have? I use plots to check distributions type of DEGREE (Y) conditional on the city of destination (X)

- I check for :
  - *Existence*
  - *strnght*
  - *patterns* / direction

Greater New York City Area San Francisco Bay Area Washington D.C. Metro Area

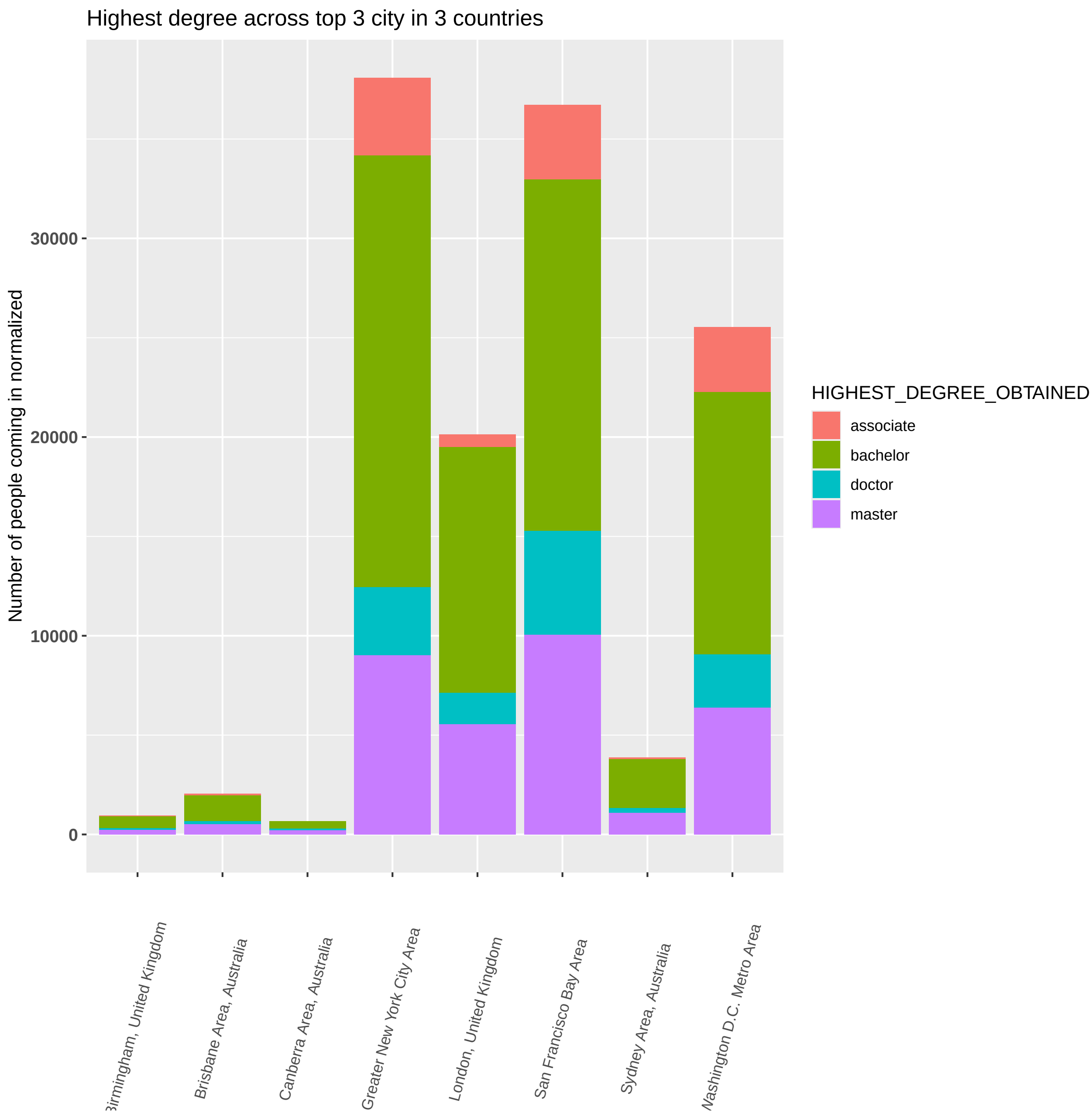
Manchester, United Kingdom London, United Kingdom Birmingham, United Kingdom

Sydney Area, Australia Brisbane Area, Australia Canberra Area, Australia

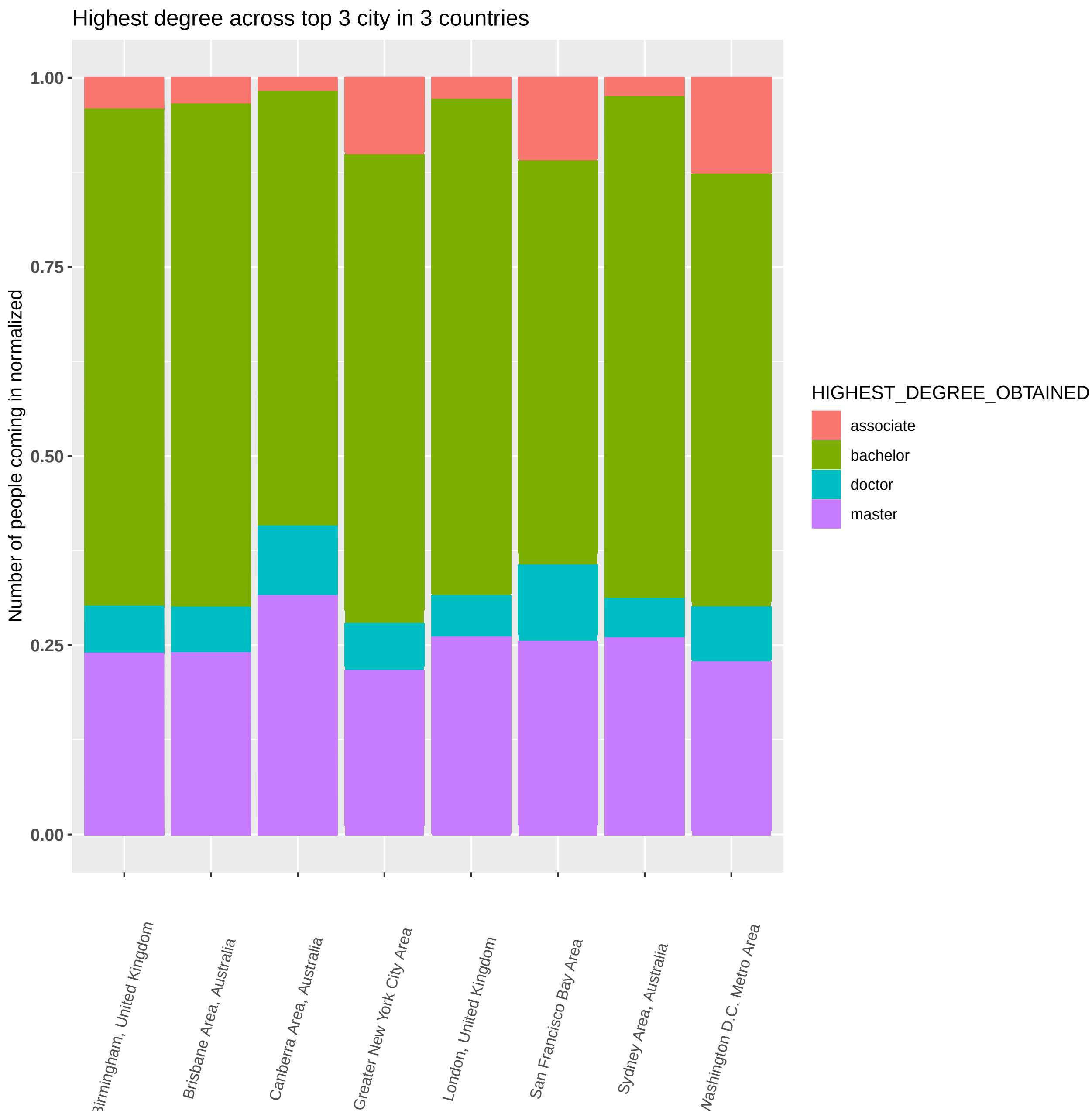
```
# 1) attempt for simplicity I select top 3 per country

#top3 <- both %>% filter(DESTINATION_REGION == "Greater New York City Area" |DESTINATION_REGION =="San

# 2) attempt

# top_subs <- subset(both, (DESTINATION_REGION == 'Greater New York City Area' | DESTINATION_REGION =='


# 3) attempt
# When subsetting with [ names are always matched exactly
```

```r
# z <- c(abc = 1, def = 2)
# z[c("a", "d")]

top_dest <- c("Greater New York City Area" , "San Francisco Bay Area",  "Washington D.C. Metro Area" ,

 # both_top <- both[as.character(  both$DESTINATION_REGION %in% top_dest), drop = T]

# data[data$Code %in% selected,]
# both_top <- both[both$DESTINATION_REGION %in% top_dest]
# both_top <- both[as.character(  both$DESTINATION_REGION %in% top_dest), drop = TRUE]

# 4) attemps
# data[data$Code == "A" | data$Code == "B", ]
top3cit <- both[both$DESTINATION_REGION == "Greater New York City Area" | both$DESTINATION_REGION == "Sa


# 5) attemps
# top_dest <- c("Greater New York City Area" , "San Francisco Bay Area",  "Washington D.C. Metro Area"


# top3cit_2 <-  both[both$DESTINATION_REGION %in%  top_dest, , drop =TRUE ]

 # mutate (Sign = ifelse(NetFlow > 0, "Positive", "Negative"))


# Explore

# mosaicplot(table(top3cit$DESTINATION_REGION, top3cit$HIGHEST_DEGREE_OBTAINED), ylab = "Political Part

# qplot
qplot(x = DESTINATION_REGION, data = top3cit, fill = HIGHEST_DEGREE_OBTAINED, geom = "bar") +
theme(axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = element_text(size=10,face="bold") 
  labs(title="Highest degree across top 3 city in 3 countries" , x="", y="Number of people coming in no
```

```
## Warning: `qplot()` was deprecated in ggplot2 3.4.0.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```




```r
# ggplot

#ggplot(data = Best_out,aes(cityD, NegOutFlow)) +
#  geom_bar(stat = "identity", position="identity", fill = "firebrick1") +
#   geom_hline(yintercept=-10000, color = "black", size=0.5) +
#  theme(axis.text.x = element_text(angle=60, vjust=0.3)) +
#  labs(title="OUT migration flow in first 15 destination")


ggplot(top3cit, aes(x=DESTINATION_REGION, y=NEW_MEM_ID, fill=HIGHEST_DEGREE_OBTAINED)) +
  geom_bar(aes(colour =HIGHEST_DEGREE_OBTAINED),stat="identity", position = "fill") +
  theme(axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = element_text(size=10,face="bold")
  labs(title="Highest degree across top 3 city in 3 countries" , x="", y="Number of people coming in no
```



- **INSIGHTs**:
  - Intuitively, it would seem San Francisco (follwed by Canberra) attracts the highest amount of doctors (Canberra also the highest group with master)
  - NY, San Francisco and Washington DC seem to receive many with “Associate” level: either young people go tehre to look for tehir first job

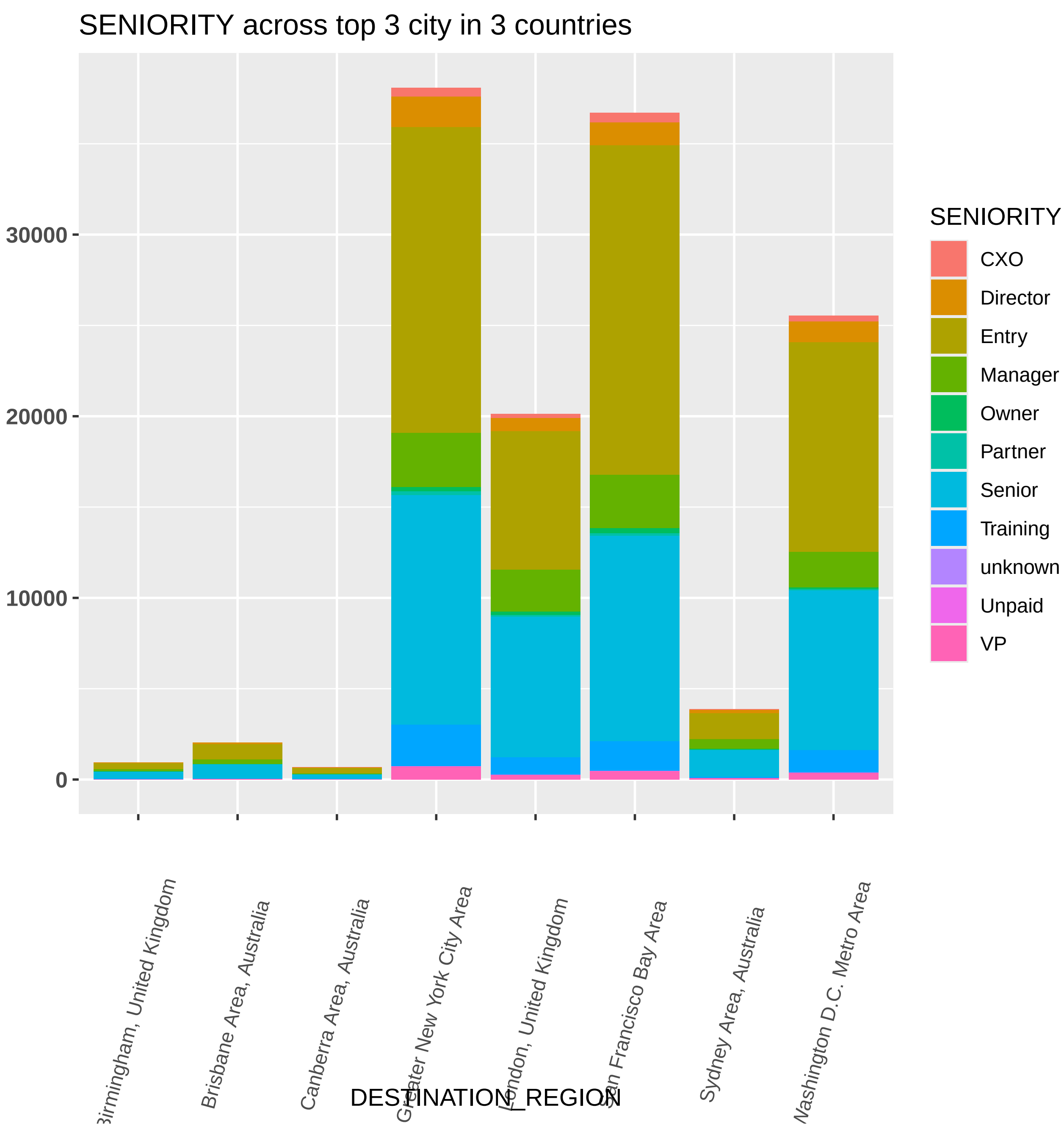
```
# cramer v   degree  X CITY OF DESTINATION (top 3)
x<- top3cit$DESTINATION_REGION
y<- top3cit$HIGHEST_DEGREE_OBTAINED

cv.test = function(x,y) {
  CV = sqrt(chisq.test(x, y, correct=FALSE)$statistic /
    (length(x) * (min(length(unique(x)),length(unique(y))) - 1)))
  print.noquote("Cramér V / Phi:")
```

```
  return(as.numeric(CV))
}

with(top3cit, cv.test(x, y)) # [1] Cramér V / Phi: 0.09052046
```

```
## [1] Cramér V / Phi:
```

```
## [1] 0.09052046
```

```
#
# mosaicplot(table(top3cit$DESTINATION_REGION, top3cit$SENIORITY), ylab = "Political Party", xlab = "Ta

# qplot
qplot(x = DESTINATION_REGION, data = top3cit, fill = SENIORITY, geom = "bar") +
theme(axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = element_text(size=10,face="bold") )
  labs(title="SENIORITY across top 3 city in 3 countries")
```



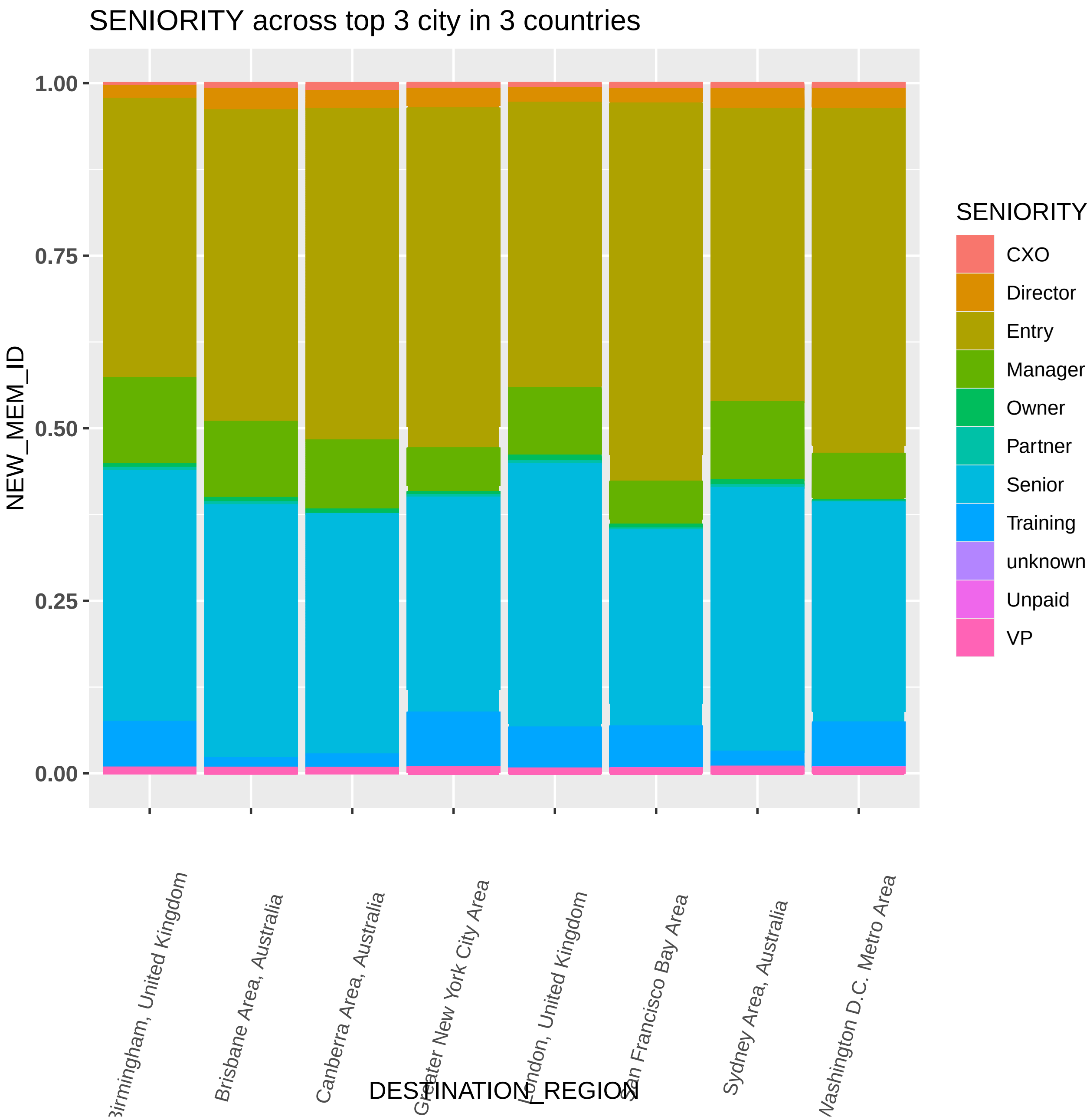

```r
# Test statistic (assuming indipendence)
chisq <- chisq.test(x = table(top3cit$DESTINATION_REGION, top3cit$SENIORITY), correct = FALSE)
```

```
## Warning in chisq.test(x = table(top3cit$DESTINATION_REGION, top3cit$SENIORITY),
## : Chi-squared approximation may be incorrect
```

```r
chisq
```

```
##
##  Pearson's Chi-squared test
##
## data:  table(top3cit$DESTINATION_REGION, top3cit$SENIORITY)
## X-squared = NaN, df = 2810, p-value = NA
```

```r
# ggplot
ggplot(top3cit, aes(x=DESTINATION_REGION, y=NEW_MEM_ID, fill=SENIORITY)) +  geom_bar(aes(colour =SENIORI
theme(axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = element_text(size=10,face="bold") 
  labs(title="SENIORITY across top 3 city in 3 countries")
```



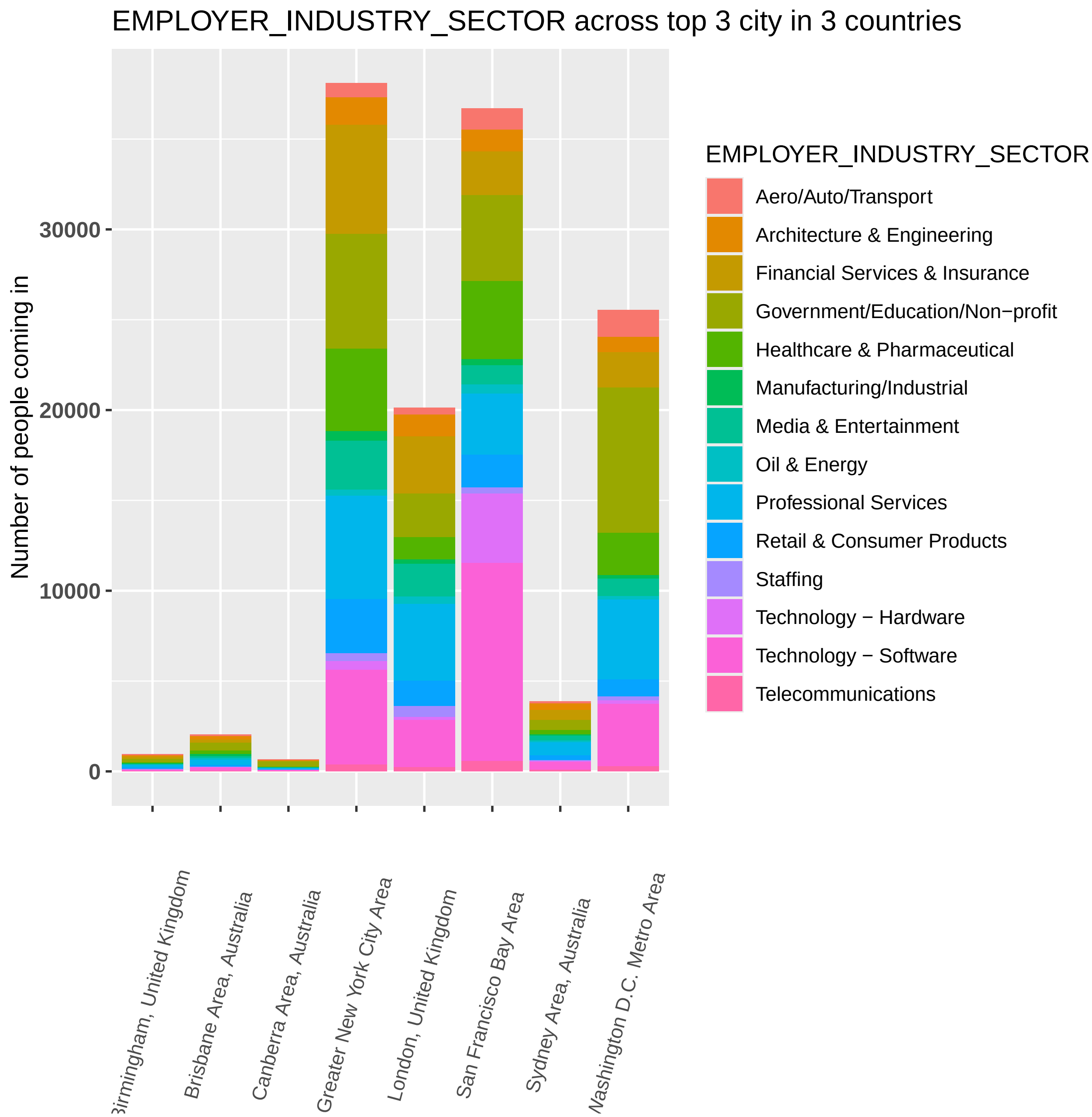
* **INSIGHTs**: + Intuitively, it would seem San Francisco (follwed by Canberra) attracts the highest amount of doctors (Canberra also the highest group with master) + NY, San Francisco and Washington DC seem to receive many with "Associate" level: either young people go tehre to look for tehir first job

```r
# cramer v    SENIORITY   X CITY OF DESTINATION (top 3)
x<- top3cit$DESTINATION_REGION
y<- top3cit$SENIORITY

cv.test = function(x,y) {
```

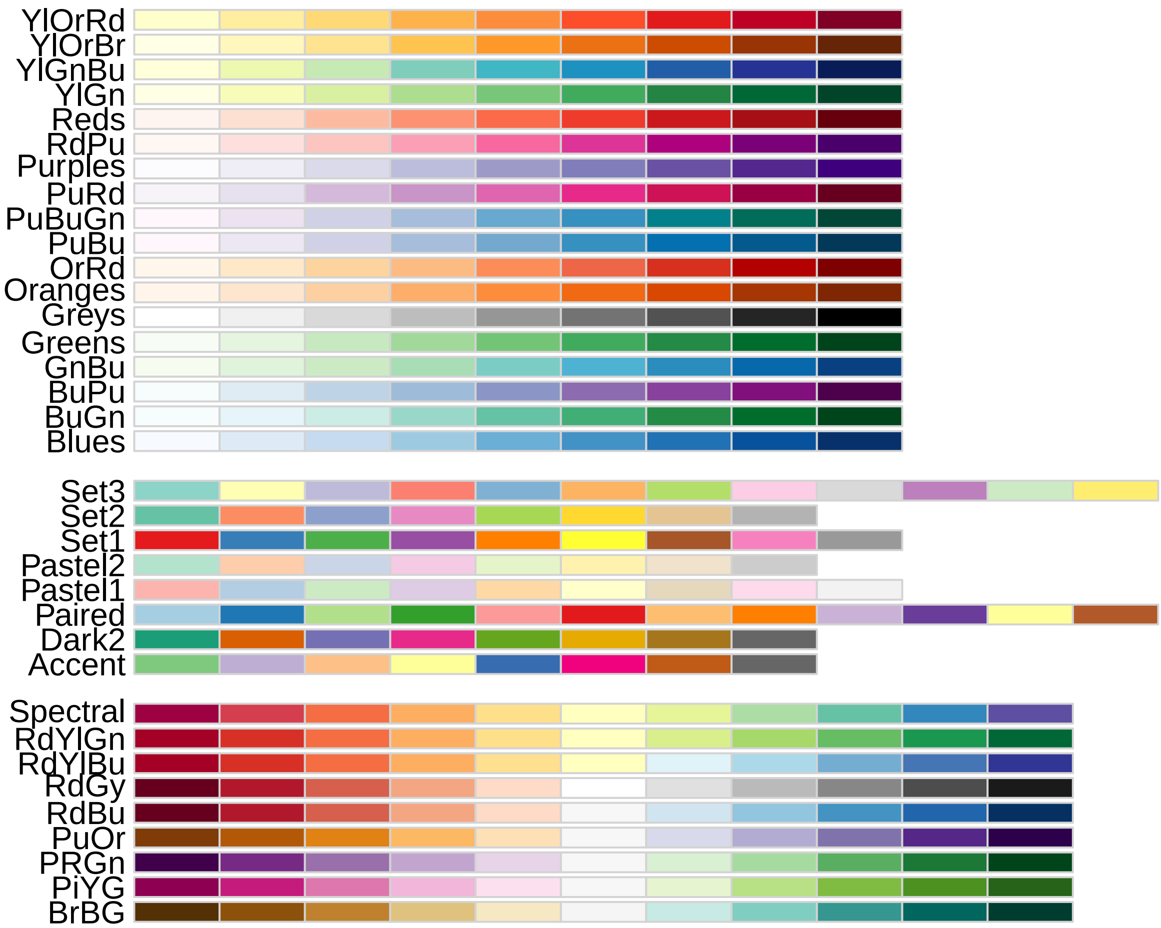
```r
  CV = sqrt(chisq.test(x, y, correct=FALSE)$statistic /
    (length(x) * (min(length(unique(x)),length(unique(y))) - 1)))
  print.noquote("Cramér V / Phi:")
  return(as.numeric(CV))
}

with(top3cit, cv.test(x, y)) # [1] Cramér V / Phi: 0.04360073
```

```
## Warning in chisq.test(x, y, correct = FALSE): Chi-squared approximation may be
## incorrect

## [1] Cramér V / Phi:

## [1] 0.04360073
```

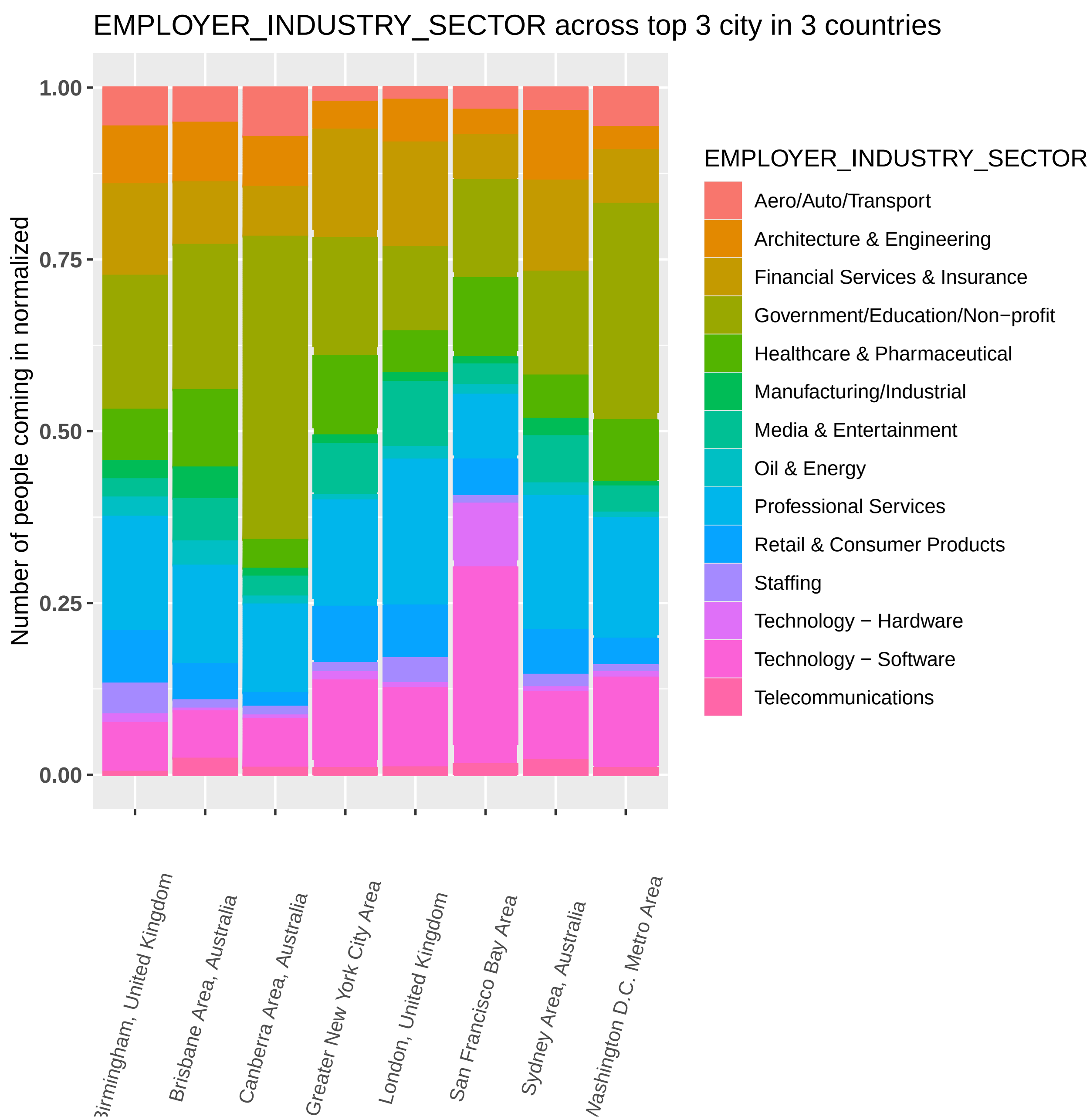
```r
#
# mosaicplot(table(top3cit$DESTINATION_REGION, top3cit$EMPLOYER_INDUSTRY_SECTOR), ylab = "Political Par

# qplot
qplot(x = DESTINATION_REGION, data = top3cit, fill = EMPLOYER_INDUSTRY_SECTOR, geom = "bar") +
theme(axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = element_text(size=10,face="bold") )
 labs(title="EMPLOYER_INDUSTRY_SECTOR across top 3 city in 3 countries", x="", y="Number of people comin
```




```r
# ggplot
library(RColorBrewer)
display.brewer.all()
```




```
ggplot(top3cit, aes(x=DESTINATION_REGION, y=NEW_MEM_ID, fill=EMPLOYER_INDUSTRY_SECTOR)) +
  geom_bar(aes(colour =EMPLOYER_INDUSTRY_SECTOR),stat="identity",  position = "fill") +
theme(legend.position = "right"     ,axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = eleme

   # scale_fill_brewer(palette = "Dark2") +
  # scale_fill_grey() +
  labs(title="EMPLOYER_INDUSTRY_SECTOR across top 3 city in 3 countries", x="", y="Number of people com
```



- **INSIGHTs**:
  - Intuitively, share of immigratns by sector seems to vary a lot in different cities
  - Extremely high number in Govv/ Educ/ Non Profit in Canberra & Washington
  - Extremely high number in Software + Hardware Technology in San Francisco
  - Extremely high number in Govv/ Educ/ Non Profit + Financial sErvices also in NY it would seem San Francisco (follwed by Canberra) attracts the highest amount of doctors (Canberra also the highest group with master)
  - NY, San Francisco and Washington DC seem to receive many with "Associate" level: either young people go tehre to look for tehir first job

CHECK A COUPLE OF CITIES FOR SECTOR X SEIORITY

```r
freq_OrigDegree <- both %>%
  group_by(both[,7],both[,2]) %>%
  summarise (n = n()) %>%
  mutate(freq = n / sum(n)) %>%
  mutate(rel.freq = paste0(round(100 * n/sum(n), 2), "%"))
```

```
## `summarise()` has grouped output by 'both[, 7]'. You can override using the
## `.groups` argument.
```

```r
freq_OrigDegree  # US has a significantly higher # of Associates leaving (18% vs 3% and 4%)
```

```
## # A tibble: 12 x 5
## # Groups:   both[, 7] [3]
##    `both[, 7]`    `both[, 2]`      n   freq rel.freq
##    <fct>          <fct>        <int>  <dbl> <chr>
##  1 Australia      associate      255 0.0286 2.86%
##  2 Australia      bachelor      5632 0.633  63.27%
##  3 Australia      doctor         611 0.0686 6.86%
##  4 Australia      master        2404 0.270  27.01%
##  5 United Kingdom associate     1312 0.0358 3.58%
##  6 United Kingdom bachelor     22107 0.604  60.38%
##  7 United Kingdom doctor        3533 0.0965 9.65%
##  8 United Kingdom master        9663 0.264  26.39%
##  9 United States  associate    79505 0.185  18.5%
## 10 United States  bachelor    225213 0.524  52.4%
## 11 United States  doctor       36358 0.0846 8.46%
## 12 United States  master       88723 0.206  20.64%
```

Cramer's V a measure of association for nominal variables. Effectively it is the Pearson chi-square statistic rescaled to have values between 0 and 1, as follows:

$$\phi_c = \sqrt{\frac{\chi^2}{N * (min(ncols, nrows) - 1)}}$$

where X^2 is the Pearson chi-square, nobs represents the number of observations included in the table, and where ncols and nrows are the number of rows and columns in the table, respectively.

For a 2 by 2 table, of course, this is just the square root of chi-square divided by the number of observations, which is also known as the ϕ coefficient.

Cramer's V varies from 0 (corresponding to no association between the variables) to 1 (complete association) and can reach 1 only when the two variables are equal to each other

```r
# cramer v   Sector X CITY OF DESTINATION (top 3)
x<- top3cit$DESTINATION_REGION
y<- top3cit$EMPLOYER_INDUSTRY_SECTOR

cv.test = function(x,y) {
  CV = sqrt(chisq.test(x, y, correct=FALSE)$statistic /
    (length(x) * (min(length(unique(x)),length(unique(y))) - 1)))
  print.noquote("Cramér V / Phi:")
  return(as.numeric(CV))
}

with(top3cit, cv.test(x, y)) # [1] Cramér V / Phi: 0.1605205
```

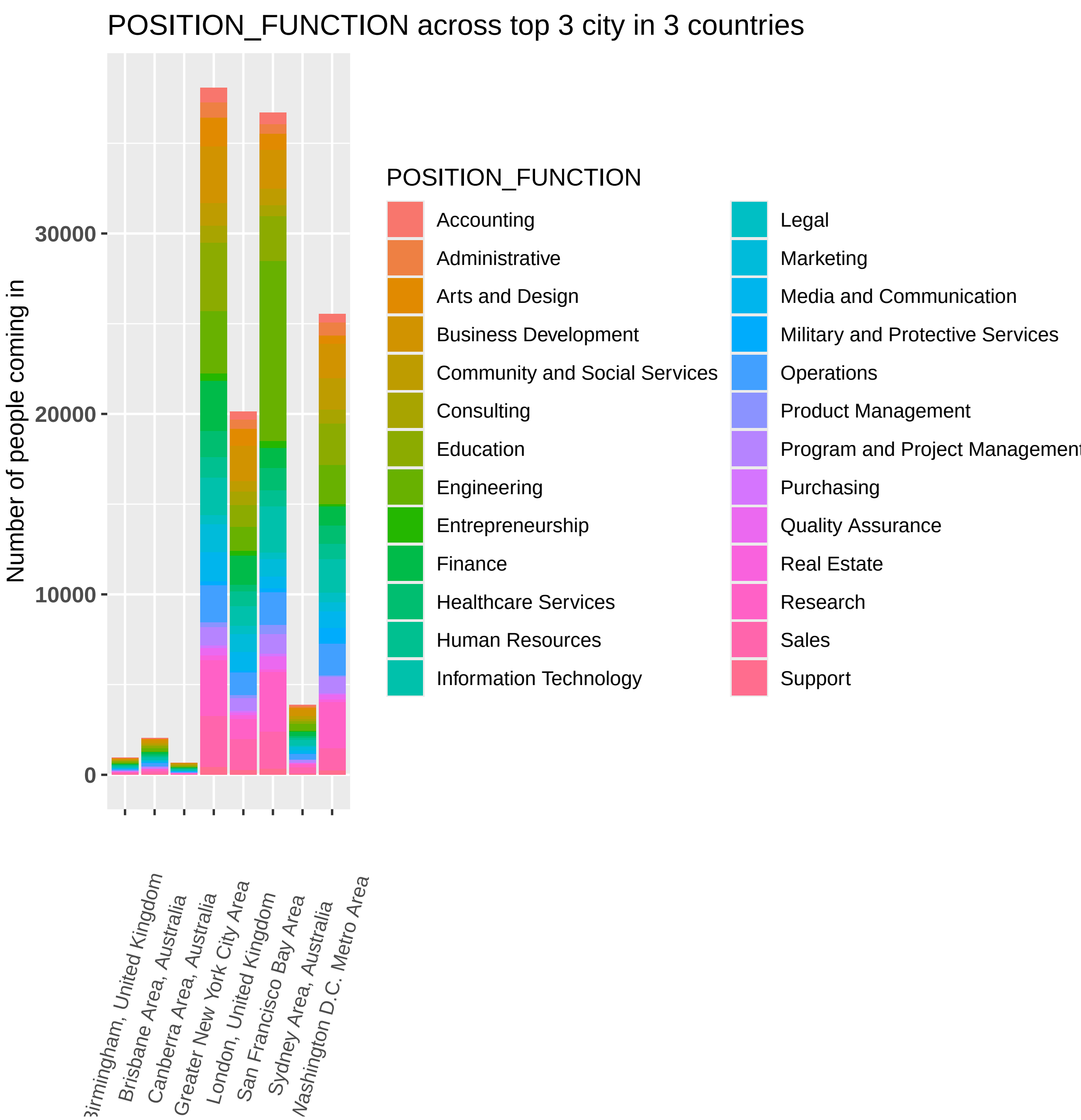
```
## [1] Cramér V / Phi:

## [1] 0.1605205
```

```r
# how about across all cities? (lower)
x<- both$DESTINATION_REGION
y<- both$EMPLOYER_INDUSTRY_SECTOR

cv.test = function(x,y) {
  CV = sqrt(chisq.test(x, y, correct=FALSE)$statistic /
    (length(x) * (min(length(unique(x)),length(unique(y))) - 1)))
  print.noquote("Cramér V / Phi:")
  return(as.numeric(CV))
}

with(both, cv.test(x, y)) # [1] Cramér V / Phi:  0.1264835
```

```
## Warning in chisq.test(x, y, correct = FALSE): Chi-squared approximation may be
## incorrect

## [1] Cramér V / Phi:

## [1] 0.1264835
```

position

```r
#
# mosaicplot(table(top3cit$DESTINATION_REGION, top3cit$POSITION_FUNCTION), ylab = "Political Party", xl

# qplot
qplot(x = DESTINATION_REGION, data = top3cit, fill = POSITION_FUNCTION, geom = "bar") +
theme(axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = element_text(size=10,face="bold") 
  labs(title="POSITION_FUNCTION across top 3 city in 3 countries" , x="", y="Number of people coming in
```



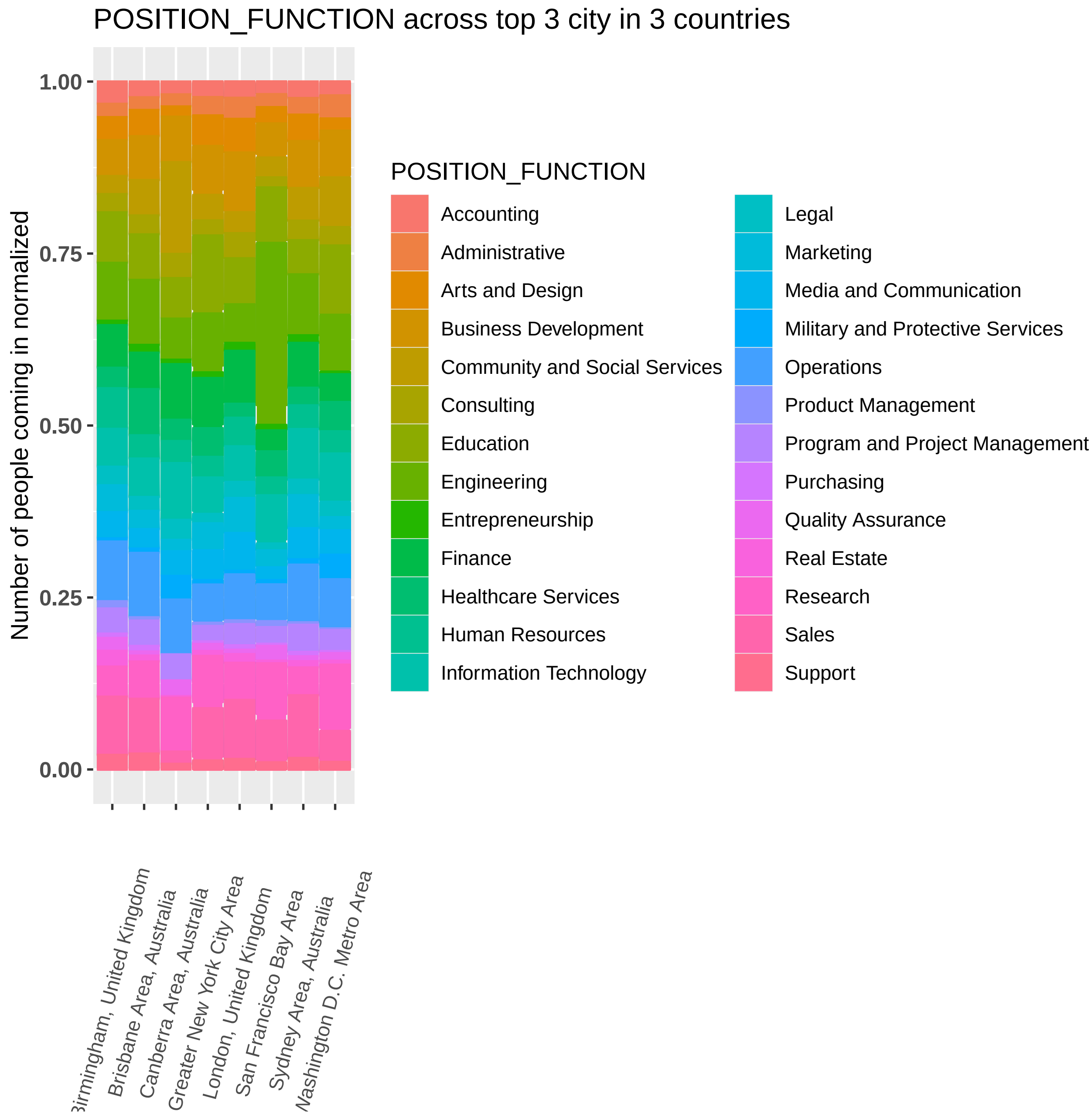

```
# Test statistic (assuming indipendence)
chisq <- chisq.test(x = table(top3cit$DESTINATION_REGION, top3cit$POSITION_FUNCTION), correct = FALSE)
```

```
## Warning in chisq.test(x = table(top3cit$DESTINATION_REGION,
## top3cit$POSITION_FUNCTION), : Chi-squared approximation may be incorrect
```

```
chisq
```

```
##
##  Pearson's Chi-squared test
##
## data:  table(top3cit$DESTINATION_REGION, top3cit$POSITION_FUNCTION)
## X-squared = NaN, df = 7025, p-value = NA
```

```r
# ggplot
ggplot(top3cit, aes(x=DESTINATION_REGION, y=NEW_MEM_ID, fill=POSITION_FUNCTION),  colour="black")    +
  geom_bar(aes(colour =POSITION_FUNCTION),stat="identity", position = "fill" )  +
theme(axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = element_text(size=10,face="bold") 
 labs(title="POSITION_FUNCTION across top 3 city in 3 countries" , x="", y="Number of people coming in r
```




```r
# cramer v   POSITION_FUNCTION X CITY OF DESTINATION (top 3)
x<- top3cit$DESTINATION_REGION
y<- top3cit$POSITION_FUNCTION

cv.test = function(x,y) {
  CV = sqrt(chisq.test(x, y, correct=FALSE)$statistic /
    (length(x) * (min(length(unique(x)),length(unique(y))) - 1)))
```

```r
  print.noquote("Cramér V / Phi:")
  return(as.numeric(CV))
}

with(top3cit, cv.test(x, y)) # [1] Cramér V / Phi: [1] 0.1318759
```

```
## Warning in chisq.test(x, y, correct = FALSE): Chi-squared approximation may be
## incorrect
```

```
## [1] Cramér V / Phi:
```

```
## [1] 0.1318759
```

```r
# how about across all cities? (lower)
x<- both$DESTINATION_REGION
y<- both$POSITION_FUNCTION

cv.test = function(x,y) {
  CV = sqrt(chisq.test(x, y, correct=FALSE)$statistic /
    (length(x) * (min(length(unique(x)),length(unique(y))) - 1)))
  print.noquote("Cramér V / Phi:")
  return(as.numeric(CV))
}

with(both, cv.test(x, y)) # [1] Cramér V / Phi:  [1] 0.07209771
```

```
## Warning in chisq.test(x, y, correct = FALSE): Chi-squared approximation may be
## incorrect
```

```
## [1] Cramér V / Phi:
```

```
## [1] 0.07209771
```

5. DOMESTIC MIGRATION

comparative analysis of domestic / patterns of internal migration in each country

I will focus on the sector per city which seems the most significant bivariate association

```r
# select only USA
both_USA <- both %>% filter(SOURCE_COUNTRY=="United States" & DESTINATION_COUNTRY=="United States")

# select only Australia
both_AUS <- both %>% filter(SOURCE_COUNTRY=="Australia" & DESTINATION_COUNTRY=="Australia")

# select only UK
both_UK <- both %>% filter(SOURCE_COUNTRY=="United Kingdom" & DESTINATION_COUNTRY=="United Kingdom")
```

construct different samples

```r
both_USA_N <- both_USA %>% group_by(DESTINATION_REGION) %>%  summarise(numIMM = n())
both_USA_N
```

construct USA internal sub-sample (for simplicity)

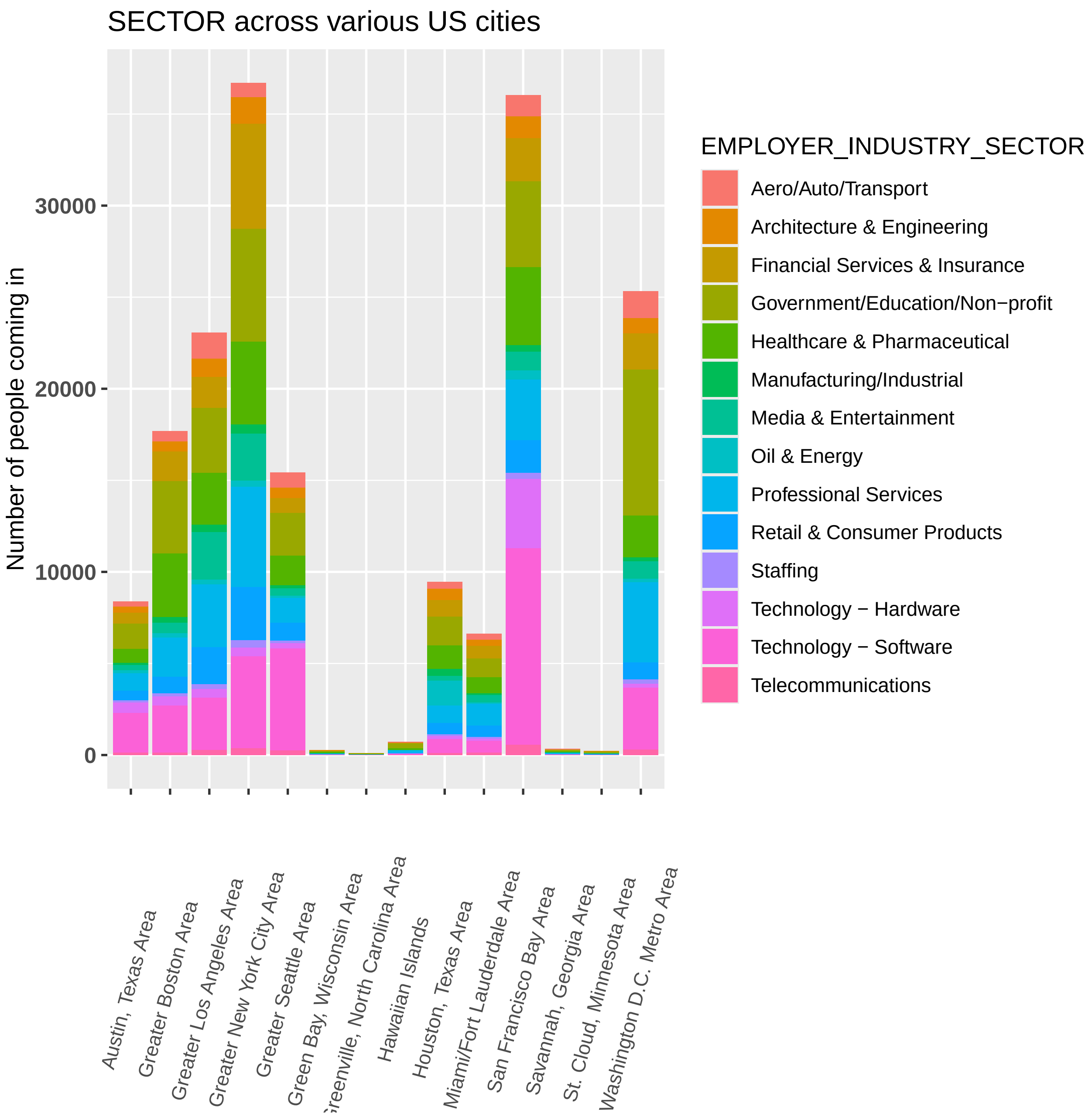
```
## # A tibble: 212 x 2
##    DESTINATION_REGION             numIMM
##    <fct>                           <int>
##  1 Abilene, Texas Area                59
##  2 Albany, New York Area            1165
##  3 Albuquerque, New Mexico Area      335
##  4 Allentown, Pennsylvania Area      728
##  5 Anchorage, Alaska Area             79
##  6 Asheville, North Carolina Area    205
##  7 Athens, Georgia Area              311
##  8 Auburn, Alabama Area               60
##  9 Augusta, Georgia Area             201
## 10 Austin, Texas Area               8401
## # i 202 more rows
```

```r
some_USA <- both_USA[both_USA$DESTINATION_REGION == "Greater New York City Area" | both_USA$DESTINATION_
                    | both_USA$DESTINATION_REGION == "Green Bay, Wisconsin Area" | both_USA$DESTINATION_
                    ,  ]

summary(some_USA)
```

```
##    NEW_MEM_ID     HIGHEST_DEGREE_OBTAINED    SENIORITY
##  Min.   :     4   associate:25165         Entry   :84953
##  1st Qu.:112192   bachelor :94375         Senior  :55988
##  Median :228366   doctor   :18926         Manager :15747
##  Mean   :231103   master   :41950         Training: 8991
##  3rd Qu.:348236                           Director: 7716
##  Max.   :475316                           VP      : 2776
##                                           (Other) : 4245
##                      EMPLOYER_INDUSTRY_SECTOR           POSITION_FUNCTION
##  Technology - Software          :33788      Engineering         :26427
##  Government/Education/Non-profit:33090      Education           :15830
##  Professional Services          :23385      Research            :15050
##  Healthcare & Pharmaceutical    :22185      Sales               :12712
##  Financial Services & Insurance :16524      Business Development:11655
##  Retail & Consumer Products     :11439      Operations          :11573
##  (Other)                        :40005      (Other)             :87169
##    WEEK_BEGINNING          SOURCE_COUNTRY                      SOURCE_REGION
##  7/31/2016:  4510   Australia     :     0   Greater New York City Area: 15572
##  8/14/2016:  4505   United Kingdom:     0   San Francisco Bay Area    : 10268
##  8/21/2016:  4493   United States :180416   Greater Los Angeles Area  :  9648
##  8/28/2016:  4354                           Greater Boston Area       :  8611
##  9/11/2016:  4327                           Washington D.C. Metro Area:  7107
##  6/5/2016 :  4289                           Greater Chicago Area      :  6984
##  (Other)  :153938                           (Other)                   :122226
##      DESTINATION_COUNTRY                   DESTINATION_REGION
##  Australia     :     0   Greater New York City Area:36695
##  United Kingdom:     0   San Francisco Bay Area    :36040
##  United States :180416   Washington D.C. Metro Area:25335
##                          Greater Los Angeles Area  :23073
##                          Greater Boston Area       :17690
##                          Greater Seattle Area      :15436
##                          (Other)                   :26147
```

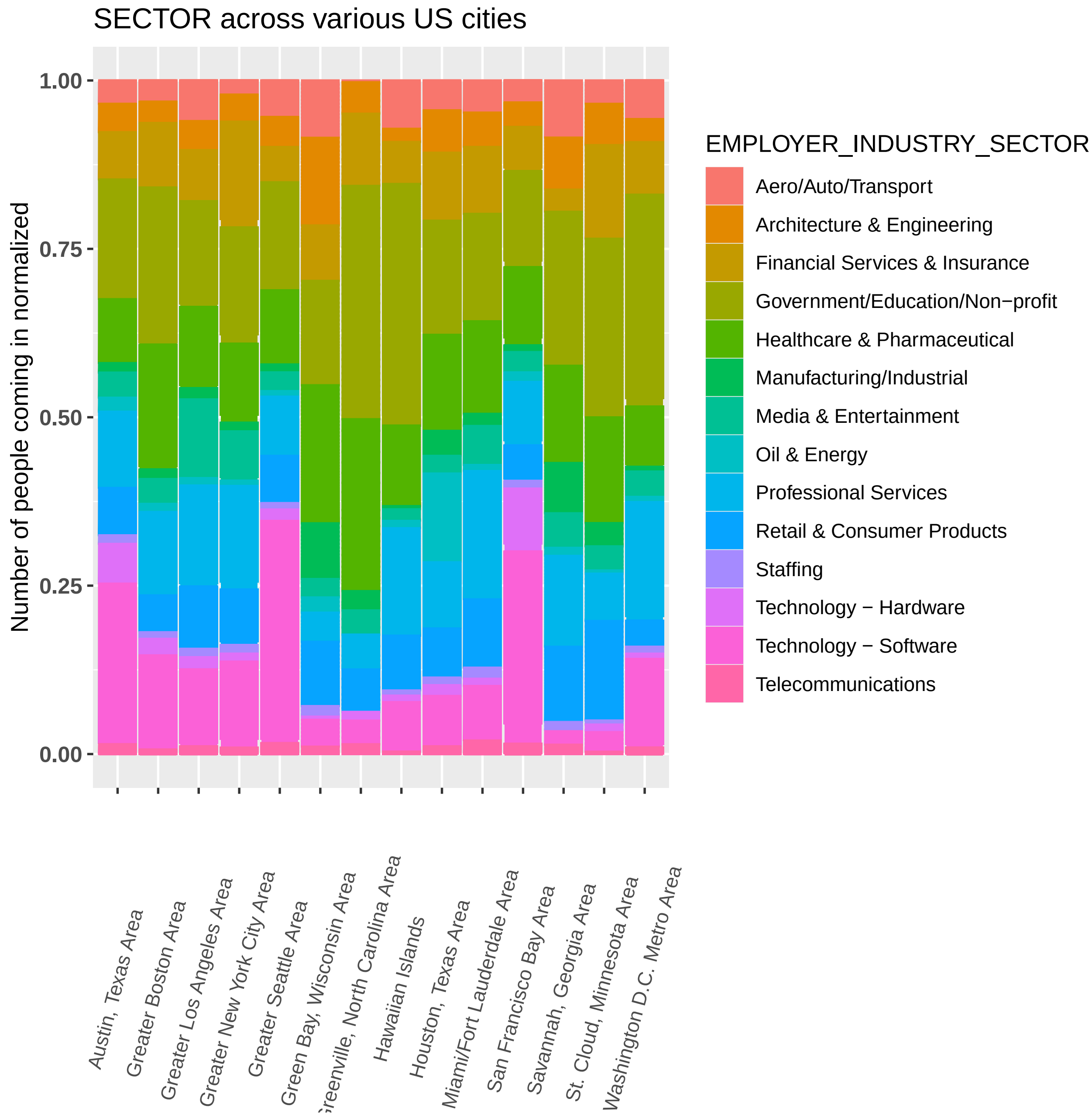
5.1 Bivariate measures of assiciation USA - sector

```
# qplot for visualization
qplot(x = DESTINATION_REGION, data = some_USA, fill = EMPLOYER_INDUSTRY_SECTOR, geom = "bar") +
theme(axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = element_text(size=10,face="bold") 
 labs(title="SECTOR across various US cities", x="", y="Number of people coming in")
```




```
# ggplot
ggplot(some_USA, aes(x=DESTINATION_REGION, y=NEW_MEM_ID, fill=EMPLOYER_INDUSTRY_SECTOR)) +
  geom_bar(aes(colour =EMPLOYER_INDUSTRY_SECTOR),stat="identity",  position = "fill") +
theme(legend.position = "right"    ,axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = eleme

   # scale_fill_brewer(palette = "Dark2") +
  # scale_fill_grey() +
```

```
  labs(title="SECTOR across various US cities", x="", y="Number of people coming in normalized")
```



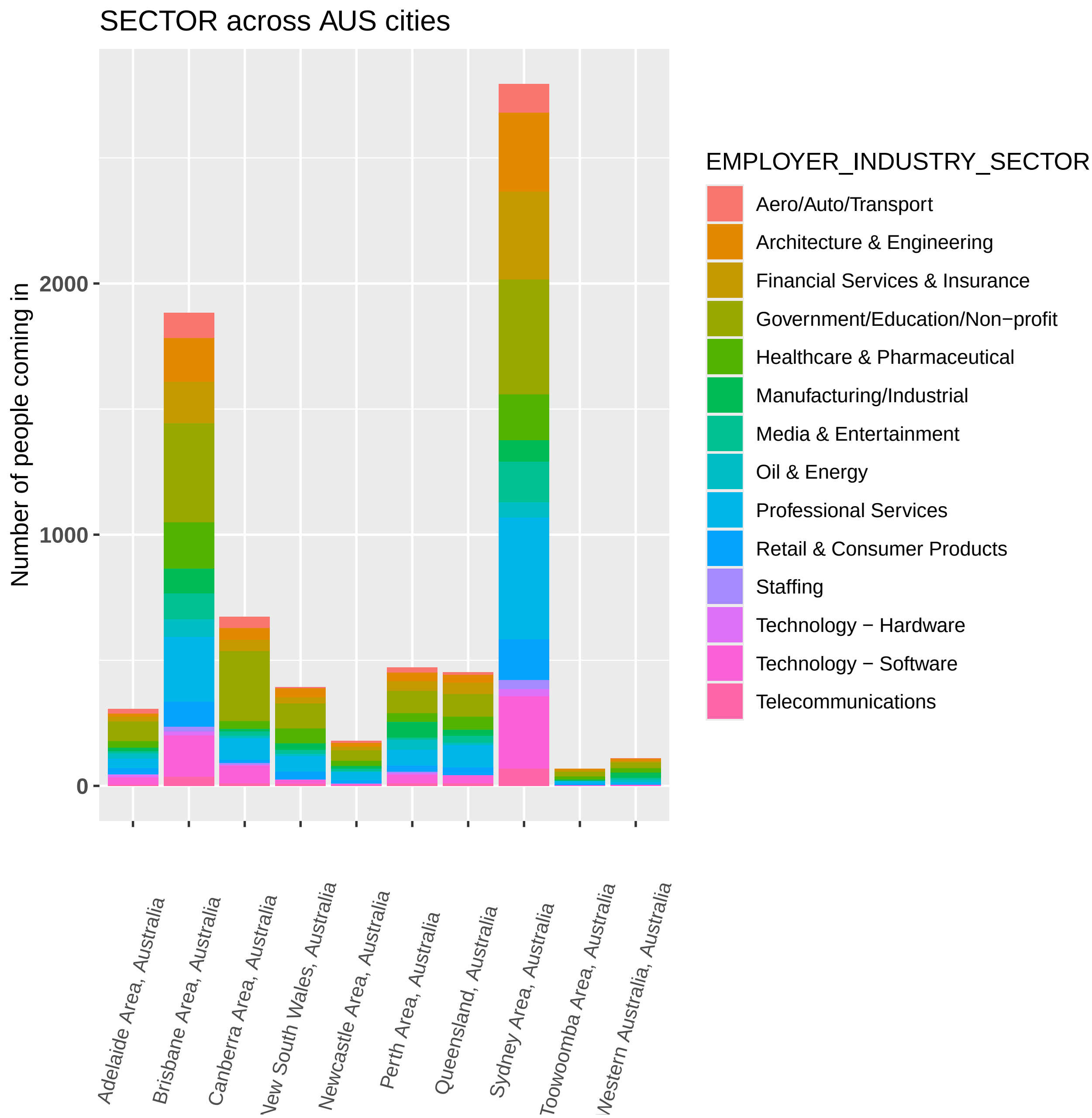

```
# cramer v   Sector X CITY OF DESTINATION (top 3)
x<- some_USA$DESTINATION_REGION
y<- some_USA$EMPLOYER_INDUSTRY_SECTOR

cv.test = function(x,y) {
  CV = sqrt(chisq.test(x, y, correct=FALSE)$statistic /
    (length(x) * (min(length(unique(x)),length(unique(y))) - 1)))
  print.noquote("Cramér V / Phi:")
  return(as.numeric(CV))
}
```

```r
with(some_USA, cv.test(x, y)) # [1] Cramér V / Phi: 0.127 (less )
```

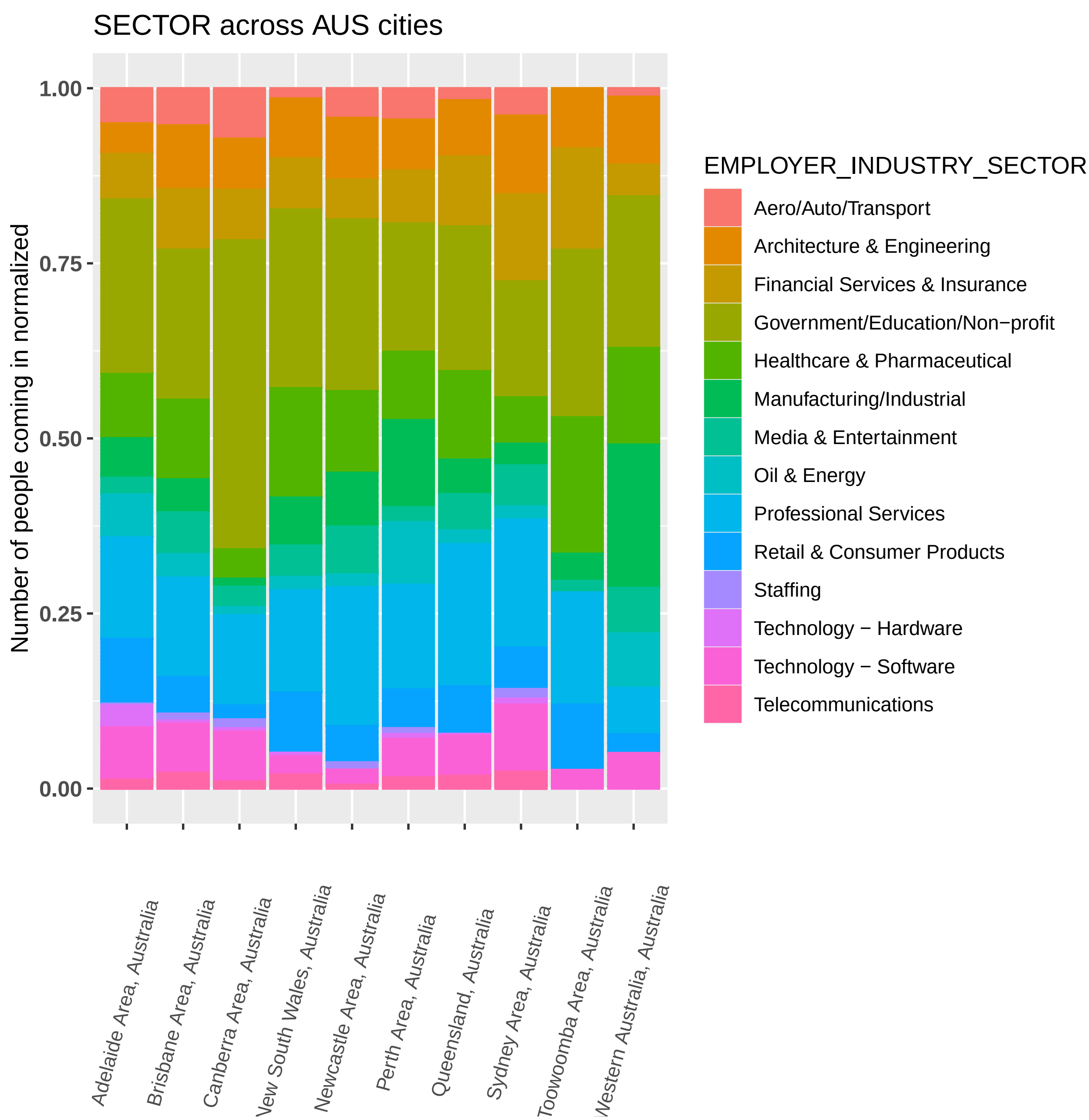
```
## Warning in chisq.test(x, y, correct = FALSE): Chi-squared approximation may be
## incorrect

## [1] Cramér V / Phi:

## [1] 0.1270301
```

5.2 Bivariate measures of association AUSTRALIA - sector

```r
# qplot for visualization
qplot(x = DESTINATION_REGION, data = both_AUS, fill = EMPLOYER_INDUSTRY_SECTOR, geom = "bar") +
theme(axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = element_text(size=10,face="bold")
 labs(title="SECTOR across AUS cities", x="", y="Number of people coming in")
```




```
# ggplot
ggplot(both_AUS, aes(x=DESTINATION_REGION, y=NEW_MEM_ID, fill=EMPLOYER_INDUSTRY_SECTOR)) +
  geom_bar(aes(colour =EMPLOYER_INDUSTRY_SECTOR),stat="identity",  position = "fill") +
theme(legend.position = "right"     ,axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = eleme

   # scale_fill_brewer(palette = "Dark2") +
  # scale_fill_grey() +
  labs(title="SECTOR across AUS cities", x="", y="Number of people coming in normalized")
```




```
# cramer v   Sector X CITY OF DESTINATION (top 3)
x<- both_AUS$DESTINATION_REGION
y<- both_AUS$EMPLOYER_INDUSTRY_SECTOR

cv.test = function(x,y) {
  CV = sqrt(chisq.test(x, y, correct=FALSE)$statistic /
    (length(x) * (min(length(unique(x)),length(unique(y))) - 1)))
  print.noquote("Cramér V / Phi:")
  return(as.numeric(CV))
}

with(both_AUS, cv.test(x, y)) # [1] Cramér V / Phi: 0.127 (less )
```

```
## Warning in chisq.test(x, y, correct = FALSE): Chi-squared approximation may be
```

```
## incorrect
## [1] Cramér V / Phi:
## [1] 0.1074171
```

5.3 Bivariate measures of association UK - sector

```
both_UK_N <- both_UK %>% group_by(DESTINATION_REGION) %>%  summarise(numIMM = n())
both_UK_N
```

construct UK internal sub-sample (for simplicity)

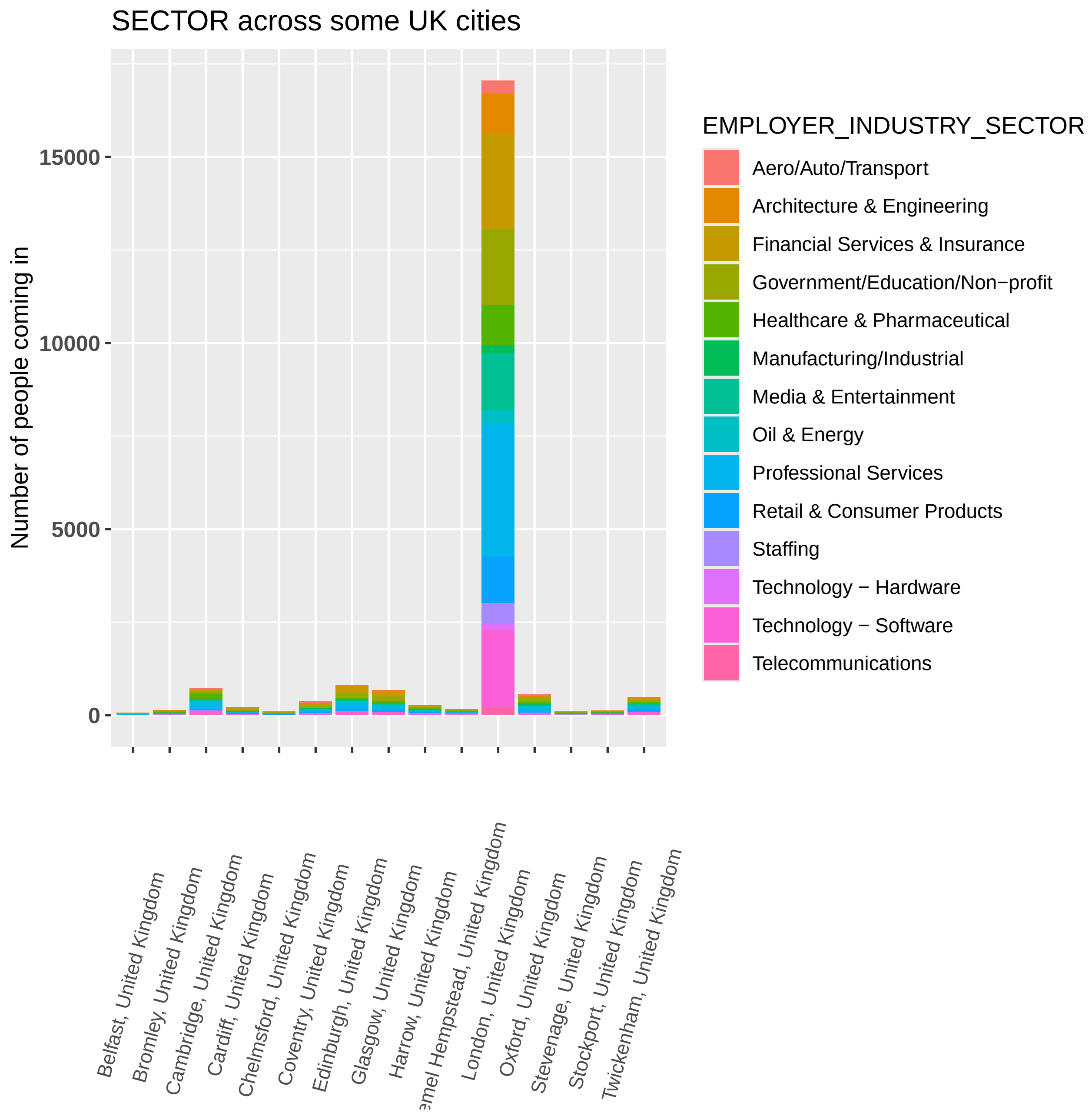
```
## # A tibble: 60 x 2
##    DESTINATION_REGION          numIMM
##    <fct>                        <int>
##  1 Bath, United Kingdom           160
##  2 Belfast, United Kingdom         66
##  3 Birmingham, United Kingdom     949
##  4 Bournemouth, United Kingdom     76
##  5 Brighton, United Kingdom       245
##  6 Bristol, United Kingdom        754
##  7 Bromley, United Kingdom        138
##  8 Cambridge, United Kingdom      719
##  9 Canterbury, United Kingdom      55
## 10 Cardiff, United Kingdom        226
## # i 50 more rows
```

```
some_UK <- both_UK[both_UK$DESTINATION_REGION == "London, United Kingdom" | both_UK$DESTINATION_REGION =
                    | both_UK$DESTINATION_REGION == "Bromley, United Kingdom" | both_UK$DESTINATION_REGI
                    ,  ]

summary(some_UK)
```

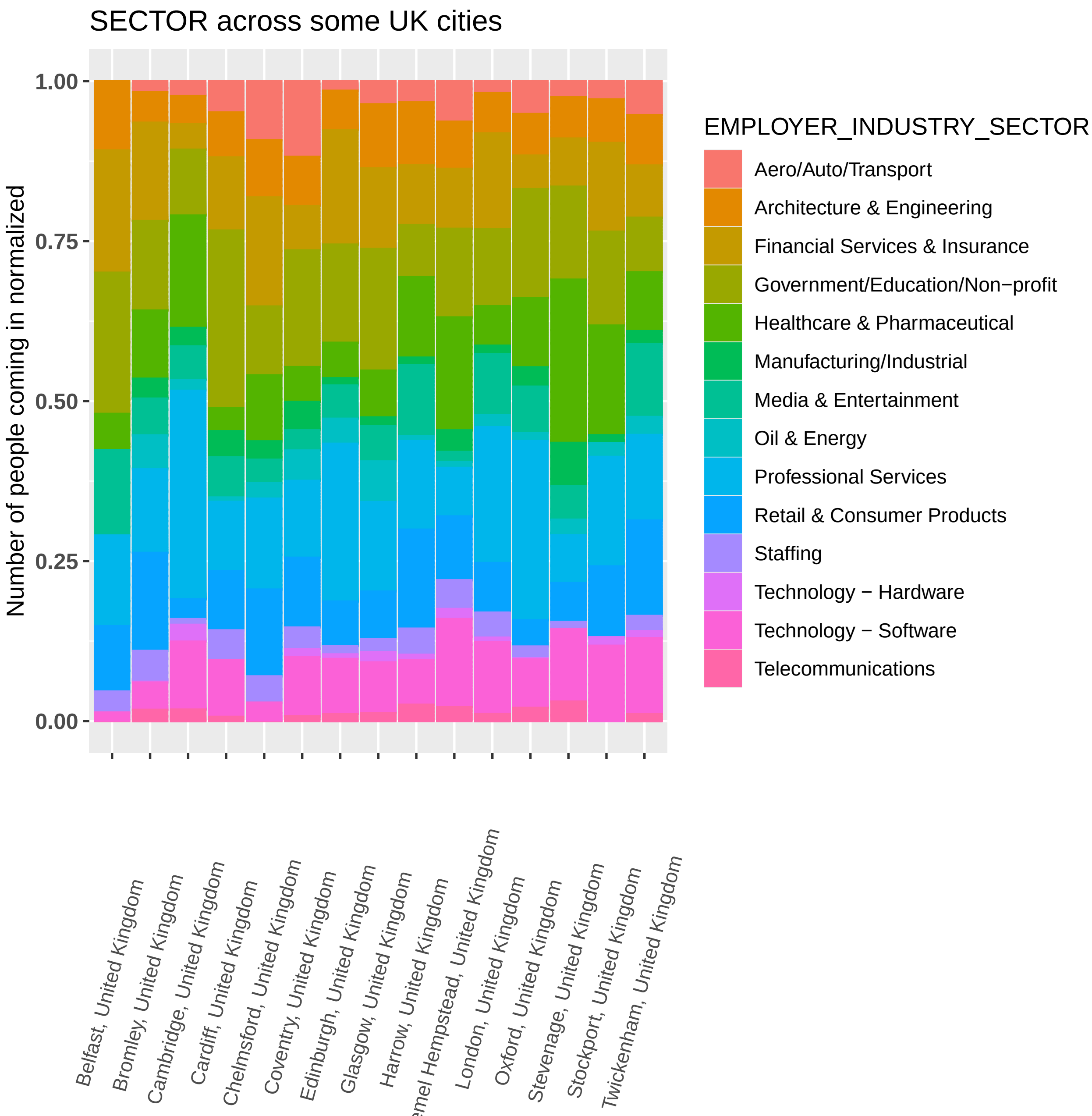
```
##    NEW_MEM_ID     HIGHEST_DEGREE_OBTAINED    SENIORITY
##  Min.   :    18   associate:  677         Entry   :8439
##  1st Qu.:163777   bachelor :13336         Senior  :8351
##  Median :286759   doctor   : 2093         Manager :2520
##  Mean   :271096   master   : 5773         Training:1057
##  3rd Qu.:385509                           Director: 754
##  Max.   :475315                           VP      : 254
##                                           (Other) : 504
##                        EMPLOYER_INDUSTRY_SECTOR            POSITION_FUNCTION
##  Professional Services           :4481        Business Development: 1927
##  Financial Services & Insurance :3093        Sales               : 1773
##  Government/Education/Non-profit:2757        Engineering         : 1572
##  Technology - Software           :2586        Finance             : 1539
##  Media & Entertainment           :1819        Operations          : 1464
##  Retail & Consumer Products      :1598        Research            : 1462
##  (Other)                         :5545        (Other)             :12142
##    WEEK_BEGINNING          SOURCE_COUNTRY
##  10/2/2016:  673   Australia     :    0
##  9/18/2016:  616   United Kingdom:21879
##  9/11/2016:  603   United States :    0
##  9/25/2016:  583
##  9/4/2016 :  575
```

```
##  10/9/2016:  565
##  (Other)  :18264
##                               SOURCE_REGION      DESTINATION_COUNTRY
##  London, United Kingdom               : 2192   Australia     :    0
##  Manchester, United Kingdom           :  816   United Kingdom:21879
##  Oxford, United Kingdom               :  767   United States :    0
##  Reading, United Kingdom              :  719
##  Twickenham, United Kingdom           :  712
##  Kingston upon Thames, United Kingdom:  699
##  (Other)                              :15974
##                   DESTINATION_REGION
##  London, United Kingdom    :17055
##  Edinburgh, United Kingdom :  803
##  Cambridge, United Kingdom :  719
##  Glasgow, United Kingdom   :  682
##  Oxford, United Kingdom    :  554
##  Twickenham, United Kingdom:  492
##  (Other)                   : 1574
```

```r
# qplot for visualization
qplot(x = DESTINATION_REGION, data = some_UK, fill = EMPLOYER_INDUSTRY_SECTOR, geom = "bar") +
theme(axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = element_text(size=10,face="bold")
 labs(title="SECTOR across some UK cities", x="", y="Number of people coming in")
```




```
# ggplot
ggplot(some_UK, aes(x=DESTINATION_REGION, y=NEW_MEM_ID, fill=EMPLOYER_INDUSTRY_SECTOR)) +
  geom_bar(aes(colour =EMPLOYER_INDUSTRY_SECTOR),stat="identity",  position = "fill") +
theme(legend.position = "right"    ,axis.text.x = element_text(angle=75, vjust=0.3), axis.text.y = elem

   # scale_fill_brewer(palette = "Dark2") +
  # scale_fill_grey() +
  labs(title="SECTOR across some UK cities", x="", y="Number of people coming in normalized")
```




```r
# cramer v   Sector X CITY OF DESTINATION (top 3)
x<- some_UK$DESTINATION_REGION
y<- some_UK$EMPLOYER_INDUSTRY_SECTOR

cv.test = function(x,y) {
  CV = sqrt(chisq.test(x, y, correct=FALSE)$statistic /
    (length(x) * (min(length(unique(x)),length(unique(y))) - 1)))
  print.noquote("Cramér V / Phi:")
  return(as.numeric(CV))
}

with(some_UK, cv.test(x, y)) # [1] Cramér V / Phi: 0.127 (less )
```

```
## Warning in chisq.test(x, y, correct = FALSE): Chi-squared approximation may be
```

```
## incorrect
## [1] Cramér V / Phi:
## [1] 0.07060599
```