Population projections using R, including graphical dynamic presentations

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Population projections using R - including graphical dynamic presentations

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Contents

1 POPULATION PROJECTIONS **3**

1.1 Introduction to population projections . . . 3

1.2 Data requirements . . . 4

1.3 Data preparation . . . 5

1.3.1 Baseline population pyramid . . . 5

1.3.2 Mortality forecast . . . 6

1.3.3 Fertility forecast . . . 8

1.4 Projection Results . . . 8

2 GRAPHICAL PRESENTATIONS **11**

2.1 How to plot a population pyramid in R? . . . 11

2.1.1 How to reverse the axis x and y ? . . . 11

2.1.2 Ho to redefine the variable scale? . . . 12

2.1.3 How to rename Axis titles? . . . 13

2.1.4 how to add a title? . . . 14

2.1.5 How to add a legend? Or any text to the plot? . . . 15

2.1.6 Other options . . . 17

2.1.7 A little bit more . . . 18

2.2 How to Make it moving moving ??? . . . 19

3 APPLICATION EXAMPLES **22**

3.1 Dynamic Total Fertility Rate projection . . . 22

3.2 Dynamic life expectancy projection: . . . 22

4 REFERENCES **23**

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In this textbook, we are going to illustrate how to perform populations projections using the Cohort-Component Method using simple R functions and without using population projections specific Packages such as popdemo. We use the Algerian population data for our case study. Then, we are going to show how to carry-out practical plots of population pyramid.

1 POPULATION PROJECTIONS

1.1 Introduction to population projections

The most practical way to make population projections consists of using the Cohort-Compnent Method. This methods consists of treating the baseline population (population at time 0) to be composed of different cohorts born in different years. So, their actual ages go from age 0 to the maximum surviving age, that we note w. Then, numbers within each cohort are projected using $prospective life tables$, and each year, new-borns are added in age . When migration and emigration data are available, population numbers are adjusted accordingly. That's where Component comes from; population dynamics is driven from the expected evolution of three components: Mortality, Fertility and Immigration.

If we set $P_{x,t}$to be the population aged x in the begenning of the year t, and $q_{x,t}$to be the Age-Specific Mortality Rate (ASMR) corresponding to x and t, the year-to-year evolution of the the population within each cohort can be driven using the equation:

$$P_{x+1,t+1} = P_{x,t} * (1 - q_{x,t})$$

The new-borns during the year $t$are added to the population of the year $t+1$ as the population aged 0. To estimate the number of new-borns during the year t, noted B_t, the mid-year population of females at the procreation ages, i.e., $15-49$years, needs to be multiplied by the Age-Specific Fertility Rates (ASFRs), $f_{x,t}$. The mid-year population can be approximated by the average population between the begenning of the years t and $t+1$. We can write.

$$B_t = \sum_{x=15}^{49} \frac{P^f x,t + P^f x,t+1}{2} * f_{x,t}$$

Then, the number of new-borns are to be split out into *boys* and *girls*. If we set "a" to be the number of boys corresponding to *one* girl among new-borns, we can split $B_t$into $B_t^m$and B_t^f, with m designs males and f females, using the equation:

$$B_t = B_t^m + B_t^f = \frac{a}{1+a} * B_t + \frac{1}{1+a} * B_t$$

a can be estimated based on the historical recorded values.

Then, $B^m t$ and $B^f t$ are introduced as populations, of males and females, at age 0 in the begenning of the year $t+1$.

1.2 Data requirements

The implementation of the Cohort-Component Method requires to make available 4 types of data: a Baseline population, projected mortality surfaces (for males and females), a projected fertility surface, and the part of males for 1 female among new-borns.

All datasets need to be extended on the period going from the reference yars, 2015 in our case, to the horizon of the projection, 2070 in our case.

We associated the datasets to this textbook as embded files which can be downloaded from the links provided below.

- Baseline population: We use the population of 2015, by detailed ages, as a baseline population.

  This population pyramid, for males and females, can also be downloaded fom :[http://www.cread.dz/Actuarial_Demography/Donnees_Site/Detailed_Ages_Proj.xlsx]

  or from:

  https://firebasestorage.googleapis.com/v0/b/gitbook-28427.appspot.com/o/assets%2F-MaJSerM8252L8AuDszJ%2F-MaK5hBKFwim5OVnotp3%2F-MaK5snkO2Tr5mJbfbfS%2Fbaseline_pop_dz_2015.txt?alt=media&token=0e1f2739-95ab-41fb-b30e-b4ee20031567

- The projected Age-Specific mortality Rates (ASMRs) from 0 to 120 years for the period from 2015 to 2017 were driven from the coherent mortality foracst of Flici (2016a) following the methodology of Hyndman et al. (2013).

  These rates can be downloaded from the following links for males

  https://firebasestorage.googleapis.com/v0/b/gitbook-28427.appspot.com/o/assets%2F-MaJSerM8252L8AuDszJ%2F-MaK5hBKFwim5OVnotp3%2F-MaK74BV_QlAkymXDuA-%2Fmort_forecast_males.txt?alt=media&token=9db67f96-2956-46f4-bad5-5a64b22c1888

  and for females

  https://firebasestorage.googleapis.com/v0/b/gitbook-28427.appspot.com/o/assets%2F-MaJSerM8252L8AuDszJ%2F-MaK5hBKFwim5OVnotp3%2F-MaK7KqDqOpbqN73xc4l%2Fmort_forecast_females.txt?alt=media&token=878ff681-d3a0-42f1-b54a-639853703dff

  The dataset of ASMRs of males and females can also be downloaded in Excel format from [http://www.cread.dz/Actuarial_Demography/Donnees_Site/Projected_ASMRs.xlsx].

- The projected Age-Specific Fertility Rates (ASFRs) for females ages 15-49 years along the period from 2015-2070 are estimated by Flici (2016b) following the methodology of Lee (1993), and can be downloaded in Excel format from: [http://www.cread.dz/Actuarial_Demography/Donnees_Site/Projected_ASFRs.xlsx].

It can also be dowloaded as a .txt file from the link: https://firebasestorage.googleapis.com/v0/b/gitbook-28427.appspot.com/o/assets%2F-MaJSerM8252L8AuDszJ%2F-MaK5hBKFwim5OVnotp3%2F-MaK7u8vEPZFeCdrX_XO%2Ffert_forecast.txt?alt=media&token=8bd4f9eb-da0d-4e48-8d71-9c4cdd91b4e6

- The international migration balance is supposed to be null.
- The number of males corresponding to 1 female among newborns is equal to 1.045 according to historical data.

1.3 Data preparation

1.3.1 Baseline population pyramid

For the needs of this work, we use the population pyramid of Algeria in the begening of 2015 for males and females for the ages 0-99 years old.

Figure 1: Baseline population dataset on excel

	A	B	C
1	2015	males	females
2	0	525931	495945
3	1	505803	474973
4	2	494789	460463
5	3	479622	437178
6	4	455602	422942
7	5	440379	400370
8	6	409459	388023
9	7	375371	376249
96	94	4042	4325
97	95	3328	3572
98	96	2688	2895
99	97	2123	2295
100	98	1636	1774
101	99	1223	1332

We upload the datafile :

```
Baseline_pop_dz_2015 <- read.table("https://firebasestorage.googleapis.com/v0/b/gitbook-28427.appspot.com/o/assets%2F-M69GC8Q928dOzF6PVLf%2F-M69J6T3gp8XoKgj42Q6%2F-M69JWbNPOq-h1hHgkYv%2Fbaseline_pop_dz_2015.txt?alt=media&token=7735f959-b6c4-43c1-a5c5-294e4825a144", header=T)
```

We separate males and females into different datasheets while changing filenames into "PM15" and "PF15" as accronyms of "Population of males 2015" and "Population of females 2015".

```
PM15<-as.matrix(Baseline_pop_dz_2015$males[1:100])
rownames(PM15)<-c(0:99)
PF15<-as.matrix(Baseline_pop_dz_2015$females[1:100])
rownames(PF15)<-c(0:99)
```

Figure 2: Baseline population of males on R

0	518601.048
1	519571.231
2	491550.703
3	497606.686
4	461301.109
5	449618.792
6	430899.838
7	387823.185
8	362752.422
9	337382.592
10	322954.195
11	319494.905
12	308646.492
13	290408.299
14	283166.798
15	286927.962
16	301681.872
17	316431.750
18	323807.596
19	331124.256

Showing 1 to 21 of 100 entries

Console Terminal

1.3.2 Mortality forecast

We need to upload the mortality surface for males and females.

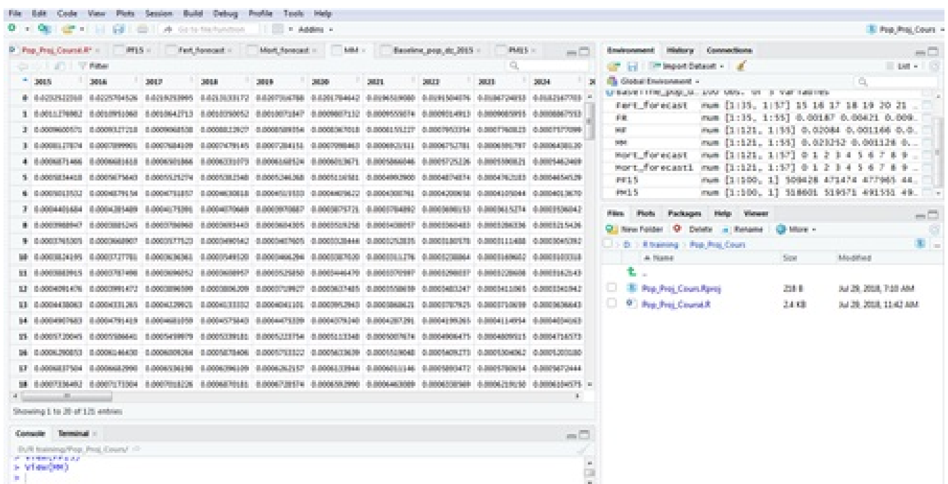
Figure 3: Mortality data matrix in Excel

	A	B	C	D	E	F	AZ	BA	BB	BC	BD	BE
1	qxm	2015	2016	2017	2018	2019	2065	2066	2067	2068	2069	2070
2	0	0,023252	0,02257	0,021925	0,021313	0,020732	0,00948	0,009389	0,009302	0,009217	0,009135	0,009056
3	1	0,001128	0,001095	0,001064	0,001035	0,001007	0,000466	0,000462	0,000457	0,000453	0,000449	0,000446
4	2	0,00096	0,000933	0,000907	0,000882	0,000859	0,000402	0,000398	0,000395	0,000391	0,000388	0,000385
5	3	0,000813	0,00079	0,000768	0,000748	0,000728	0,000345	0,000342	0,000339	0,000336	0,000333	0,00033
6	4	0,000687	0,000668	0,00065	0,000633	0,000617	0,000296	0,000293	0,00029	0,000288	0,000286	0,000283
118	116	0,79005	0,788674	0,787939	0,78701	0,786069	0,763555	0,763555	0,763555	0,763555	0,763555	0,763555
119	117	0,838963	0,837855	0,837269	0,836524	0,835769	0,81761	0,81761	0,81761	0,81761	0,81761	0,81761
120	118	0,890218	0,889426	0,889011	0,88848	0,887942	0,874933	0,874933	0,874933	0,874933	0,874933	0,874933
121	119	0,943877	0,943452	0,943232	0,942949	0,942662	0,935677	0,935677	0,935677	0,935677	0,935677	0,935677
122	120	1	1	1	1	1	1	1	1	1	1	1

Male mortality

```
MM<- read.table("https://firebasestorage.googleapis.com/v0/b/gitbook-28427.appspot.com/o/
assets%2F-M69GC8Q928d0zF6PVLf%2F-M69J6T3gp8XoKgj42Q6%2F-M69J_65GSqJfyB1hQZ4%2FMort_forec
ast_males.txt?alt=media&token=ce303331-93ca-40ce-b2a3-fb50dfcc0bea", header=T)
   MM<-as.matrix(MM[1:121,2:57])
   rownames(MM)<-c(0:120)
   colnames(MM)<-c(2015:2070)
```

Figure 4: Mortality datamatrix being uploaded to R

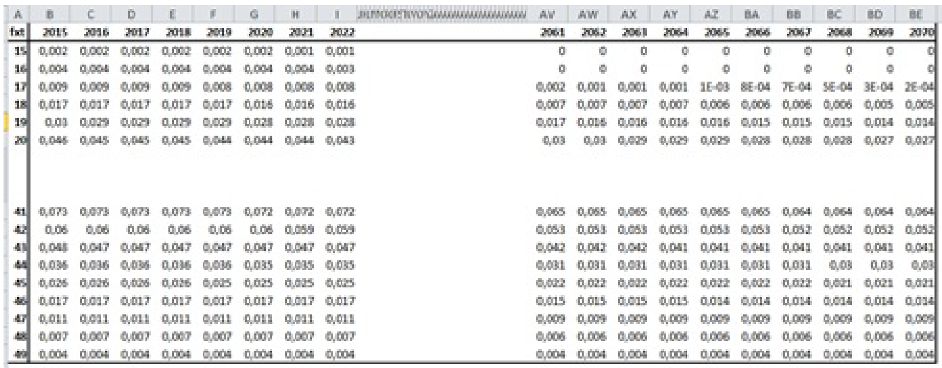


Female Mortality

```
 MF<- read.table("https://firebasestorage.googleapis.com/v0/b/gitbook-28427.appspot.com/
o/assets%2F-M69GC8Q928d0zF6PVLf%2F-M69J6T3gp8XoKgj42Q6%2F-M69JamiW2fVfbZC0gia%2FMort_for
ecast_females.txt?alt=media&token=8454d5f6-3270-45a0-826c-09de6bfe750d", header=T)
    MF<- as.matrix(MF[1:121,2:57])
    rownames(MF)<-c(0:120)
    colnames(MF)<-c(2015:2070)
```

1.3.3 Fertility forecast

Figure 5: Fertility datamatrix in Excel



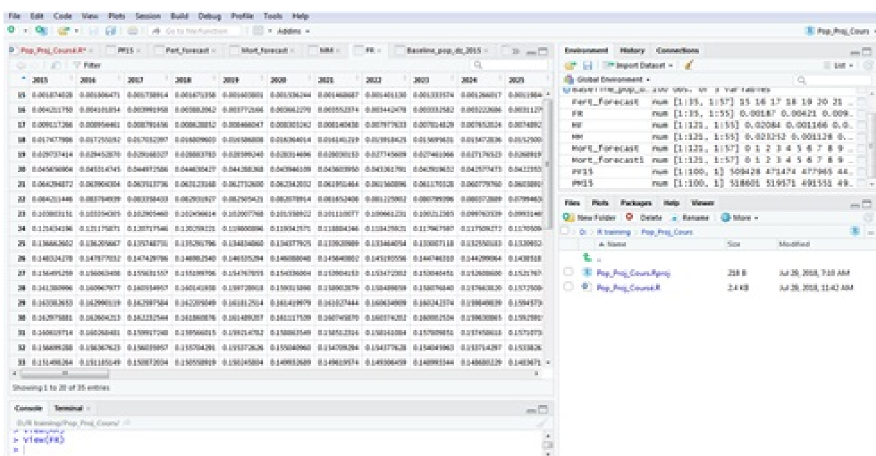
A	B	C	D	E	F	G	H	I
fxt	2015	2016	2017	2018	2019	2020	2021	2022
15	0,002	0,002	0,002	0,002	0,002	0,002	0,001	0,001
16	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,003
17	0,009	0,009	0,009	0,009	0,008	0,008	0,008	0,008
18	0,017	0,017	0,017	0,017	0,017	0,016	0,016	0,016
19	0,03	0,029	0,029	0,029	0,029	0,028	0,028	0,028
20	0,046	0,045	0,045	0,045	0,044	0,044	0,044	0,043
41	0,073	0,073	0,073	0,073	0,073	0,072	0,072	0,072
42	0,06	0,06	0,06	0,06	0,06	0,06	0,059	0,059
43	0,048	0,047	0,047	0,047	0,047	0,047	0,047	0,047
44	0,036	0,036	0,036	0,036	0,036	0,035	0,035	0,035
45	0,026	0,026	0,026	0,026	0,025	0,025	0,025	0,025
46	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017
47	0,011	0,011	0,011	0,011	0,011	0,011	0,011	0,011
48	0,007	0,007	0,007	0,007	0,007	0,007	0,007	0,007
49	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004

A	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE
fxt	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	0,002	0,001	0,001	0,001	1E-03	8E-04	7E-04	5E-04	3E-04	2E-04
18	0,007	0,007	0,007	0,007	0,006	0,006	0,006	0,006	0,005	0,005
19	0,017	0,016	0,016	0,016	0,016	0,015	0,015	0,015	0,014	0,014
20	0,03	0,03	0,029	0,029	0,029	0,028	0,028	0,028	0,027	0,027
41	0,065	0,065	0,065	0,065	0,065	0,065	0,064	0,064	0,064	0,064
42	0,053	0,053	0,053	0,053	0,053	0,053	0,052	0,052	0,052	0,052
43	0,042	0,042	0,042	0,041	0,041	0,041	0,041	0,041	0,041	0,041
44	0,031	0,031	0,031	0,031	0,031	0,031	0,031	0,03	0,03	0,03
45	0,022	0,022	0,022	0,022	0,022	0,022	0,022	0,021	0,021	0,021
46	0,015	0,015	0,015	0,015	0,014	0,014	0,014	0,014	0,014	0,014
47	0,009	0,009	0,009	0,009	0,009	0,009	0,009	0,009	0,009	0,009
48	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006
49	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004

Upload the data file, and we name it as (FR) as "Fertility".

```
FR<-read.table("https://firebasestorage.googleapis.com/v0/b/gitbook-28427.appspot.com/o/assets%2F-M69GC8Q928d0zF6PVLf%2F-M69J6T3gp8XoKgj42Q6%2F-M69JcV0tWsH-GQUmIiu%2FFert_forecast.txt?alt=media&token=cc90ae5b-dcae-49d9-86e6-b9244fd4549d", header=T)
FR<- as.matrix(FR[1:35, 2:57])
rownames(FR)<-c(15:49)
colnames(FR)<-c(2015:2070)
```

Figure 6: Fertility datamatrix being uploaded to R



1.4 Projection Results

First, we create an ampty matrix to receive the projection results (PopM for males and PopF for females). This matrix should be of a dimension $(n = 121 by t = 56)$

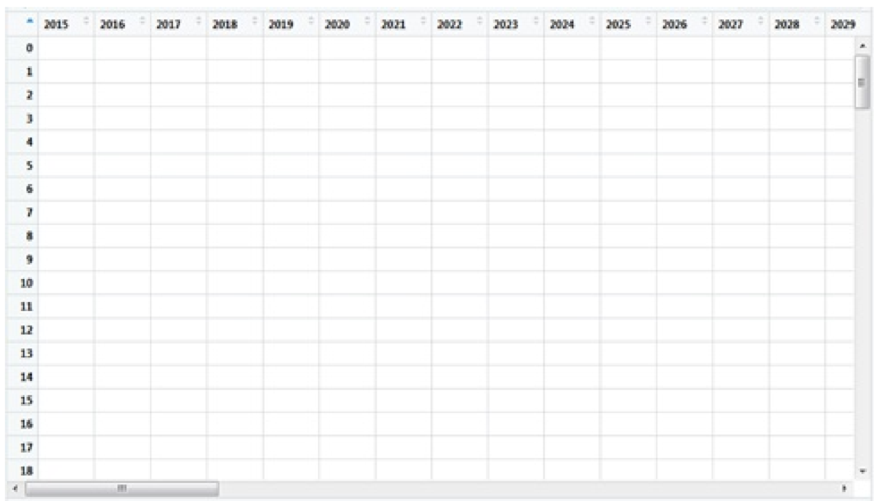
```
PopM<-matrix(0,nrow=121,ncol=56)
rownames(PopM)<-c(0:120)
```

```
colnames(PopM)<-c(2015:2070)
```

Then,

```
PopF<-matrix(0,nrow=121,ncol=56)
rownames(PopF)<-c(0:120)
colnames(PopF)<-c(2015:2070)
```

Figure 7: Create and Ampty matrix in R



Then, we copy the PM15 into the first row in PopM (PF15 into PopF)

```
PopM[1:121,1]<-rbind(PM15, as.matrix(rep(0,21), ncol=1,nrow=21))
PopF[1:121,1]<-rbind(PF15,as.matrix(rep(0,21),ncol=1,nrow=21))
PopM<-as.matrix(PopM)
PopF<-as.matrix(PopF)
```

The projection of population number by age is deduced by a year to year approach by applying the survival probabilities. If we not to be the probablity to die (Age Specific Mortality Rates) between the ages and during the year , the population at age during the year noted is deduced from :

$$P_{x+1,t+1} = P_{x,t} * (1 - q_{x,t})$$

.

The population at age in the begenning of the year is estimated by the total of newborns during the previous years, i.e., year , (noted) on the basis of combining the population (Mid-year population rather than that of the begening of the year) of females at fertility age (years : noted with the age specific fertility rates ASFRs (noted). We can write :

$$B_{t-1} = \sum_{s=15}^{49} PFM_{s,t-1} * f_{s,t-1}$$

We estimate the Mid-year population (PFM as an average of the populations at the begening and the end of the previous year). It makes:

$$B_{t-1} = \sum_{s=15}^{49} \frac{PF_{s,t-1} + PF_{s,t}}{2} * f_{s,t-1}$$

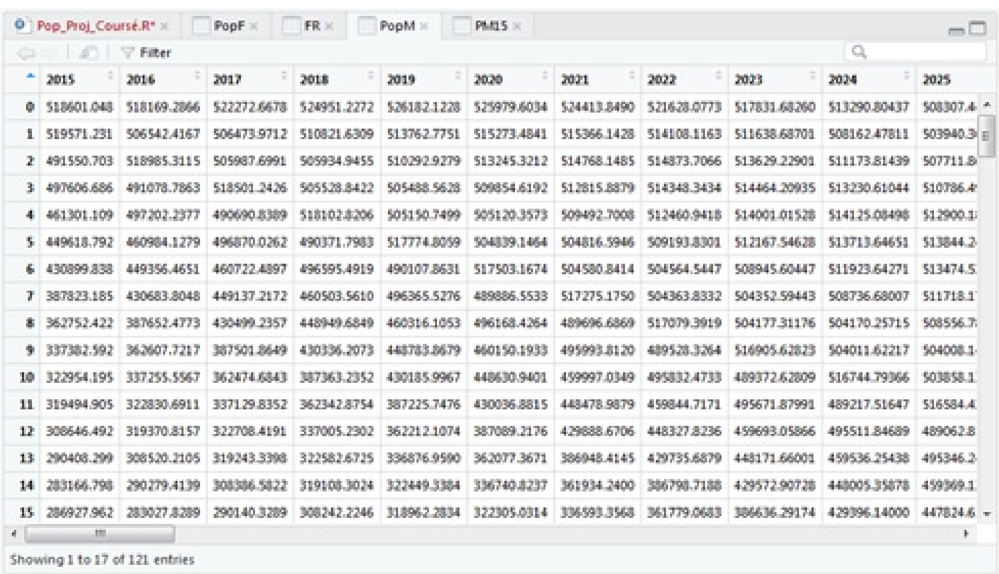
In order to separate males and females among the newborns, we introduce (define) which represents the number of males aong newborn corresponding to female.

```
a=1.045
```

The part of males among a cohort of newborns is equal to $B * \frac{a}{1+a}$ while the number of females is equal to $B * \frac{1}{1+a}$. The newborns during the year are introduced as the population of age in the begenning of year .

```
 for (i in 2 :  56) {
 for (j in 2:  121) {PopM[j,i]<-PopM[j-1,i-1]*(1-MM[j-1,i-1])
 PopF[j,i]<-PopF[j-1,i-1]*(1-MF[j-1,i-1])
}
 PopM[1,i]<-as.matrix(t(PopF[16:50,i-1]+PopF[16:50,i])/2)%*%as.matrix(
FR[,i-1])*(a/(1+a))
 PopF[1,i]<-as.matrix(t(PopF[16:50,i-1]+PopF[16:50,i])/2)%*%as.matrix(
FR[,i-1])*(1/(1+a)) }
```

Figure 8: The projection matrix being filled out



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
0	518601.048	518169.2866	522272.6678	524951.2272	526182.1228	525979.6034	524413.8490	521628.0773	517831.68260	513290.80437	508307.4
1	519571.231	506542.4167	506473.9712	510821.6309	513762.7751	515273.4841	515366.1428	514108.1163	511638.68701	508162.47811	503940.3
2	491550.703	518985.3115	505987.6991	505934.9455	510292.9279	513245.3212	514768.1485	514873.7066	513629.22901	511173.81439	507711.8
3	497606.686	491078.7863	518501.2426	505528.8422	505488.5628	509854.6192	512815.8879	514348.3434	514464.20935	513230.61044	510786.4
4	461301.109	497202.2377	490690.8389	518102.8206	505150.7499	505120.3573	509492.7008	512460.9418	514001.01528	514125.08498	512900.1
5	449618.792	460984.1279	496870.0262	490371.7983	517774.8059	504839.1464	504816.5946	509193.8301	512167.54628	513713.64651	513844.2
6	430899.838	449356.4651	460722.4897	496595.4919	490107.8631	517503.1674	504580.8414	504564.5447	508945.60447	511923.64271	513474.5
7	387823.185	430683.8048	449137.2172	460503.5610	496365.5276	489886.5533	517275.1750	504363.8332	504352.59443	508736.68007	511718.1
8	362752.422	387652.4773	430499.2357	448949.6849	460316.1053	496168.4264	489696.6869	517079.3919	504177.31176	504170.25715	508556.7
9	337382.592	362607.7217	387501.8649	430336.2073	448783.8679	460150.1933	495993.8120	489528.3264	516905.62823	504011.62217	504008.1
10	322954.195	337255.5567	362474.6843	387363.2352	430185.9967	448630.9401	459997.0349	495832.4733	489372.62809	516744.79366	503858.1
11	319494.905	322830.6911	337129.8352	362342.8754	387225.7476	430036.8815	448478.9879	459844.7171	495671.87991	489217.51647	516584.4
12	308646.492	319370.8157	322708.4191	337005.2302	362212.1074	387089.2176	429888.6706	448327.8236	459693.05866	495511.84689	489062.8
13	290408.299	308520.2105	319243.3398	322582.6725	336876.9590	362077.3671	386948.4145	429735.6879	448171.66001	459536.25438	495346.2
14	283166.798	290279.4139	308386.5822	319108.3024	322449.3384	336740.8237	361934.2400	386798.7188	429572.90728	448005.35878	459369.1
15	286927.962	283027.8289	290140.3289	308242.2246	318962.2834	322305.0314	336593.3568	361779.0683	386636.29174	429396.14000	447824.6

2 GRAPHICAL PRESENTATIONS

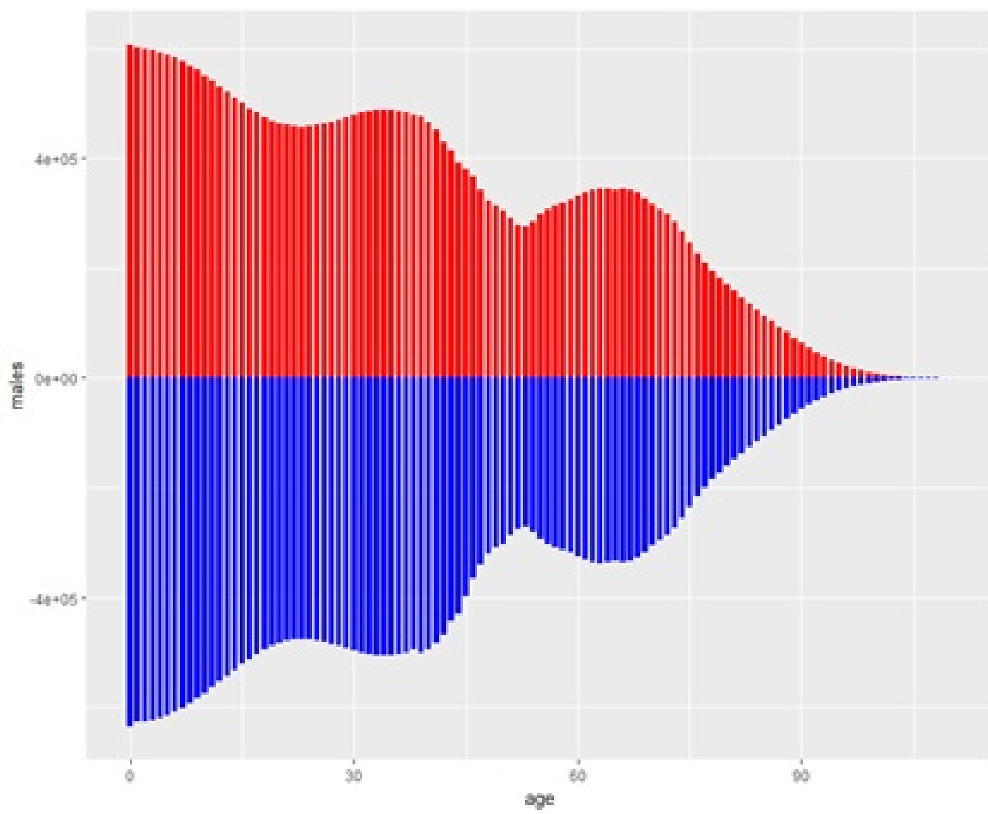
2.1 How to plot a population pyramid in R?

First, we need to call *ggplot*

A first example

```
i<-40
   year1<-as.character(2015+i)
   pyram<-cbind.data.frame(seq(0,110,1),-PopM[1:111,i],PopF[1:111,i])
   colnames(pyram)<-c("age","males","females")
   A<-ggplot(pyram, aes(x=age))
   B<-A+ geom_bar(aes(y=males),fill="blue",stat="identity",width=0.75)
   C<- B+ geom_bar(aes(y=females),fill="red",stat="identity",width=0.75)
   print(C)
```

Figure 9: Population Pyramid - a first example

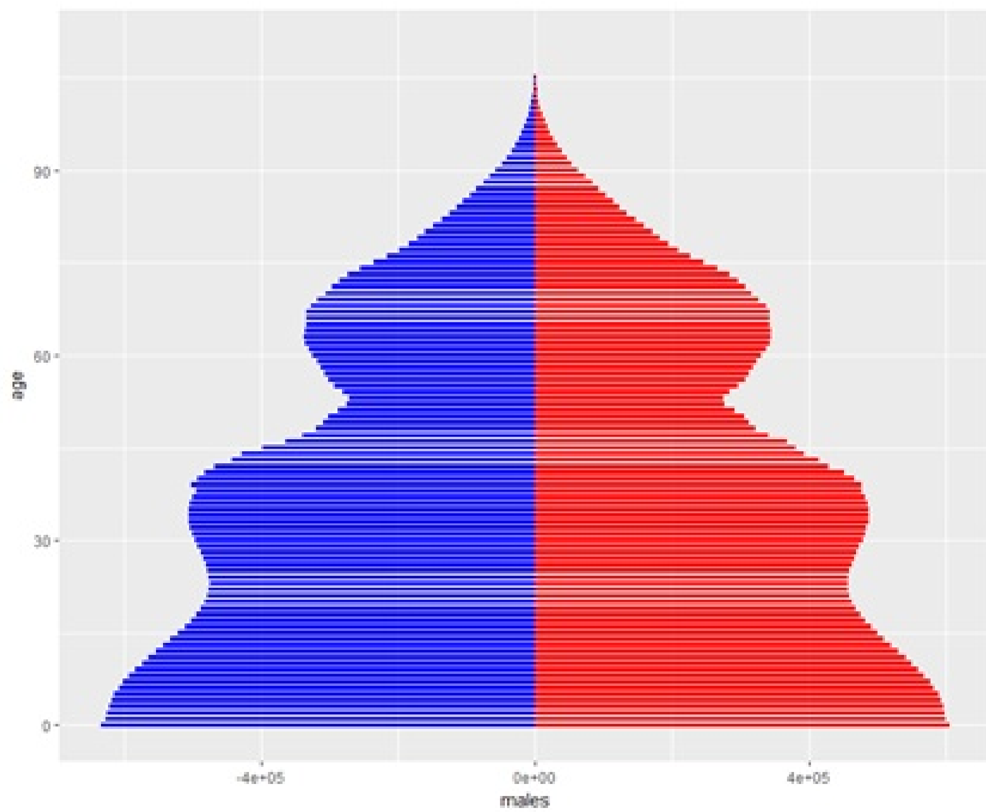


2.1.1 How to reverse the axis x and y ?

by adding `+ coord_flip()`

```
i<-40
year1<-as.character(2015+i)
pyram<-cbind.data.frame(seq(0,110,1),-PopM[1:111,i],PopF[1:111,i])
colnames(pyram)<-c("age","males","females")
A<-ggplot(pyram, aes(x=age))
B<-A+ geom_bar(aes(y=males),fill="blue",stat="identity",width=0.75)
C<- B+ geom_bar(aes(y=females),fill="red",stat="identity",width=0.75)
D<- C+coord_flip()
print(D)
```

Figure 10: Population Pyramid with axes being rotated 90^o



2.1.2 Ho to redefine the variable scale?

by adding

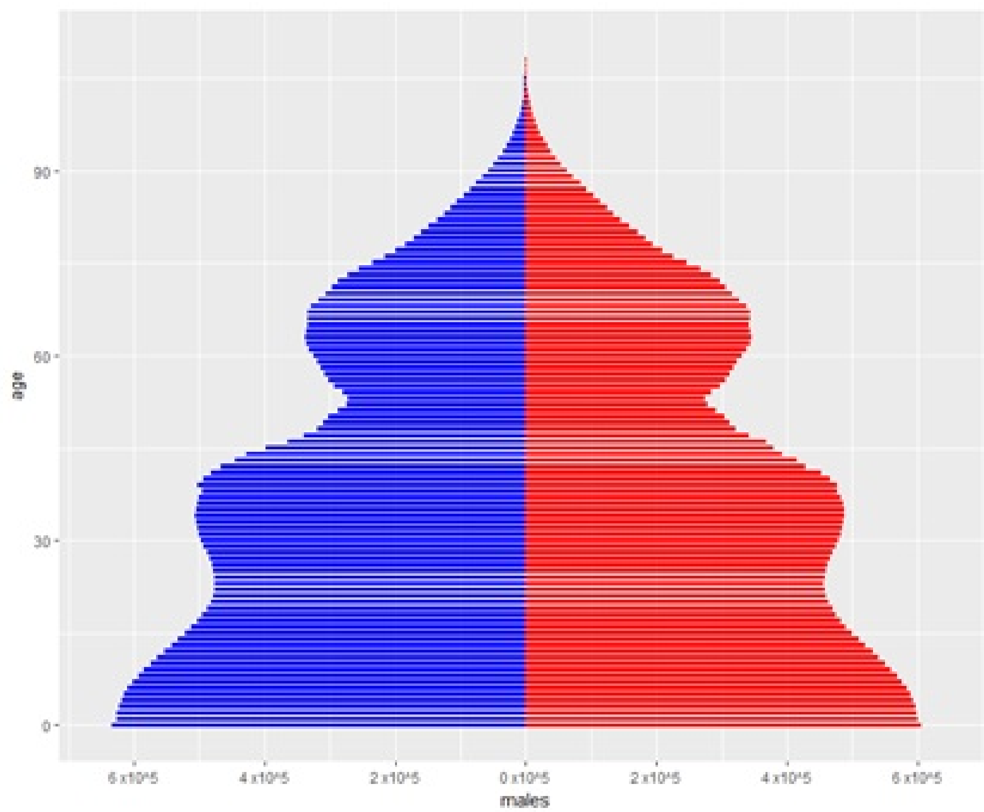
```
+ scale_y_continuous(breaks = seq(-600000, 600000, 200000),
labels = paste(as.character(c(seq(6, 0, -2),seq(2,6,2))), "x10^5"),
limits=c(-650000,650000))
```

It makes :

```
i<-40
```

```
year1<-as.character(2015+i)
pyram<-cbind.data.frame(seq(0,110,1),-PopM[1:111,i],PopF[1:111,i])
colnames(pyram)<-c("age","males","females")
A<-ggplot(pyram, aes(x=age))
B<-A+ geom_bar(aes(y=males),fill="blue",stat="identity",width=0.75)
C<- B+ geom_bar(aes(y=females),fill="red",stat="identity",width=0.75)
D<- C+coord_flip()
E<-D+ scale_y_continuous(breaks = seq(-600000, 600000, 200000),
labels = paste(as.character(c(seq(6, 0, -2),seq(2,6,2))), "$x10^5$"),
limits=c(-650000,650000))
print(E)
```

Figure 11: Population Pyramid with axes scale being redefined



2.1.3 How to rename Axis titles?

by adding

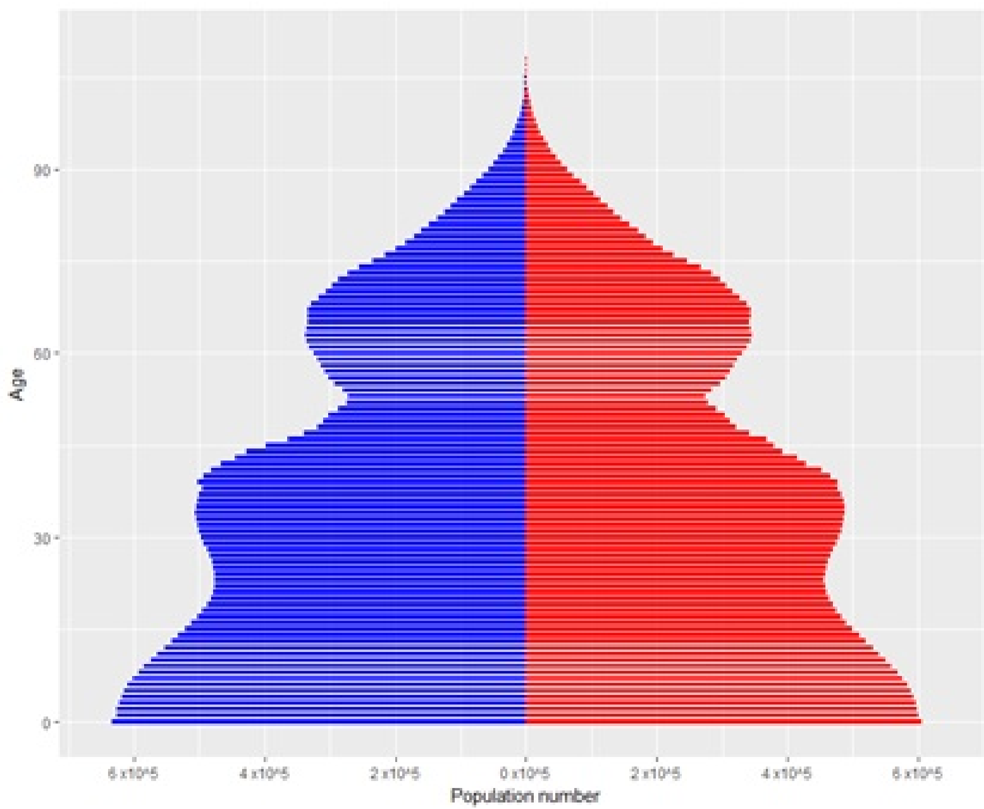
```
+ xlab("Age") + ylab("Population number")
```

It makes :

```
i<-40
```

```
year1<-as.character(2015+i)
pyram<-cbind.data.frame(seq(0,110,1),-PopM[1:111,i],PopF[1:111,i])
colnames(pyram)<-c("age","males","females")
A<-ggplot(pyram, aes(x=age))
B<-A+ geom_bar(aes(y=males),fill="blue",stat="identity",width=0.75)
C<- B+ geom_bar(aes(y=females),fill="red",stat="identity",width=0.75)
D<- C+coord_flip()
E<-D+ scale_y_continuous(breaks = seq(-600000, 600000, 200000),
labels = paste(as.character(c(seq(6, 0, -2),seq(2,6,2))), "x10^5"),
limits=c(-650000,650000))
F<-E+ xlab("Age") + ylab("Population number")
print(F)
```

Figure 12: Population Pyramid with axes being labelled



2.1.4 how to add a title?

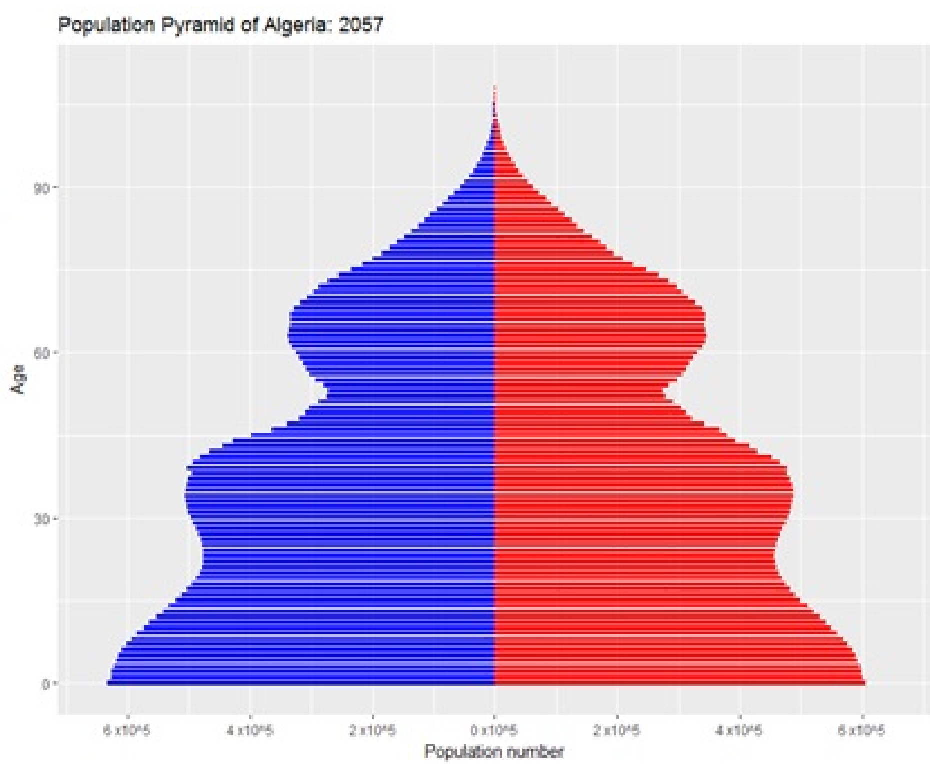
by adding

```
+ ggtitle(paste("Population Pyramid of Algeria:", year1)
```

It makes :

```
i<-40
year1<-as.character(2015+i)
pyram<-cbind.data.frame(seq(0,110,1),-PopM[1:111,i],PopF[1:111,i])
colnames(pyram)<-c("age","males","females")
A<-ggplot(pyram, aes(x=age))
B<-A+ geom_bar(aes(y=males),fill="blue",stat="identity",width=0.75)
C<- B+ geom_bar(aes(y=females),fill="red",stat="identity",width=0.75)
D<- C+coord_flip()
E<-D+ scale_y_continuous(breaks = seq(-600000, 600000, 200000),
labels = paste(as.character(c(seq(6, 0, -2),seq(2,6,2))), "x10^5"),
limits=c(-650000,650000))
F<-E+ xlab("Age") + ylab("Population number")
G<-F+ ggtitle(paste("Population Pyramid of Algeria:", year1)))
print(G)
```

Figure 13: Population Pyramid with title being added



2.1.5 How to add a legend? Or any text to the plot?

by adding

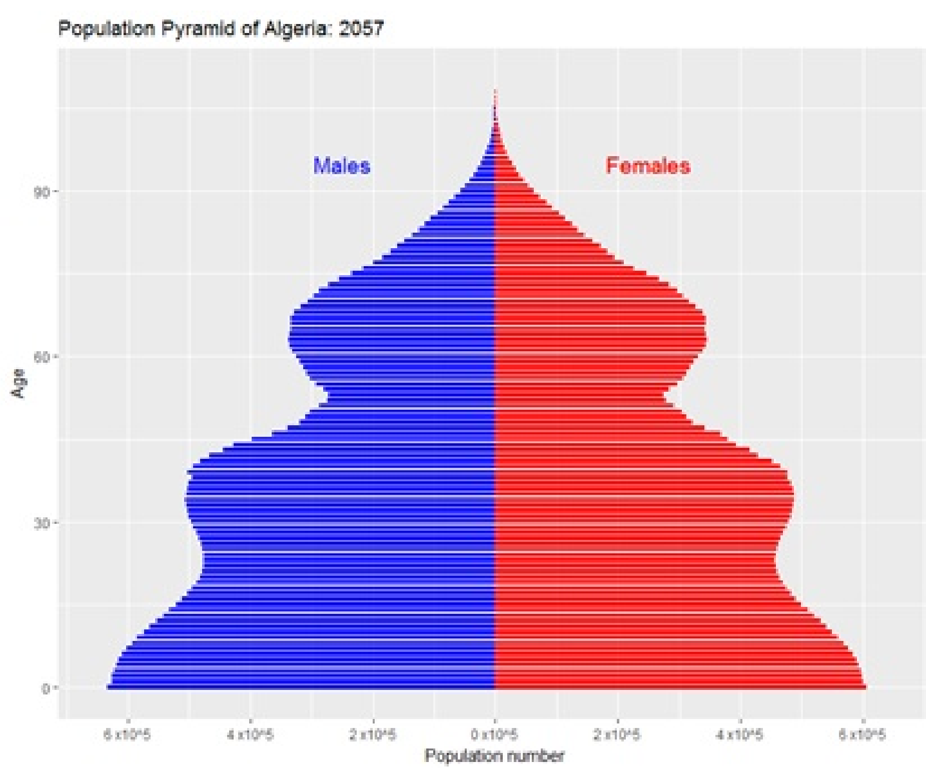
```
+ annotate('text', x = 95, y = 250000, label = 'Females', size = 5,
```

```
colour="red")
```

It makes :

```
i<-40
year1<-as.character(2015+i)
pyram<-cbind.data.frame(seq(0,110,1),-PopM[1:111,i],PopF[1:111,i])
colnames(pyram)<-c("age","males","females")
A<-ggplot(pyram, aes(x=age))
B<-A+ geom_bar(aes(y=males),fill="blue",stat="identity",width=0.75)
C<- B+ geom_bar(aes(y=females),fill="red",stat="identity",width=0.75)
D<- C+coord_flip()
E<-D+ scale_y_continuous(breaks = seq(-600000, 600000, 200000),
labels = paste(as.character(c(seq(6, 0, -2),seq(2,6,2))), "x10^5"),
limits=c(-650000,650000))
F<-E+ xlab("Age") + ylab("Population number")
G<-F+ ggtitle(paste("Population Pyramid of Algeria:", year1)))
H<-G+ annotate('text', x = 95, y = 250000, label = 'Females', size = 5,
colour="red")
print(H)
```

Figure 14: Population Pyramid with legend/text being added



2.1.6 Other options

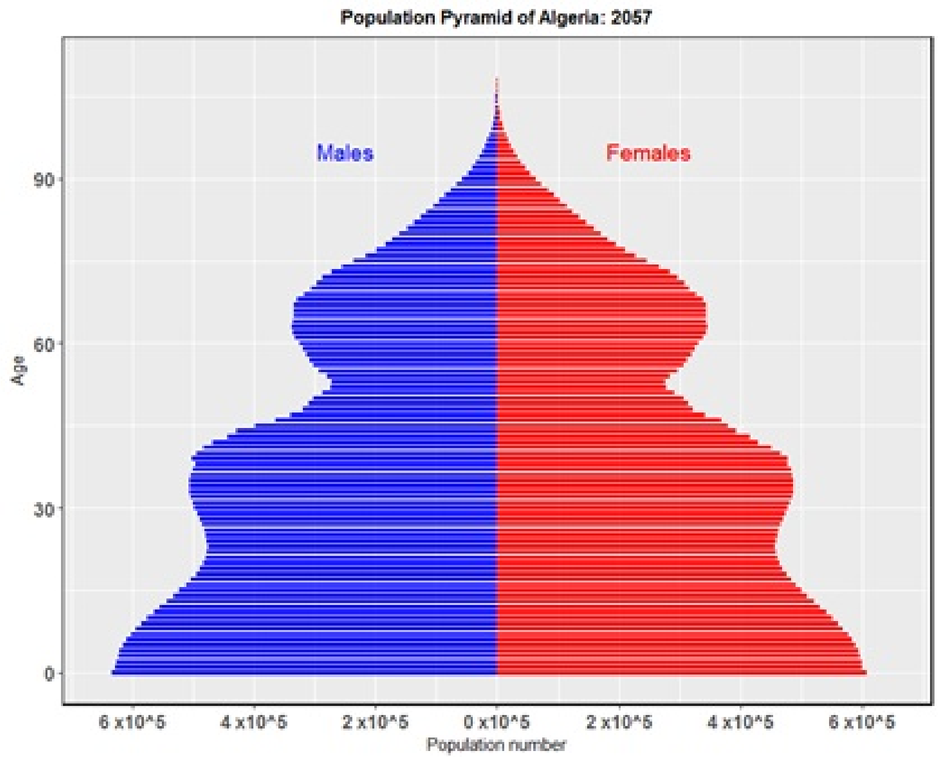
by adding

```
+theme(plot.title = element_text(hjust = 0.5,size=12,face="bold"),
panel.border = element_rect(colour = "black",fill=NA,size=1),
axis.text = element_text(size=12,face="bold"), panel.background =
element_rect(fill="white")))
```

It makes :

```
i<-40
year1<-as.character(2015+i)
pyram<-cbind.data.frame(seq(0,110,1),-PopM[1:111,i],PopF[1:111,i])
colnames(pyram)<-c("age","males","females")
A<-ggplot(pyram, aes(x=age))
B<-A+ geom_bar(aes(y=males),fill="blue",stat="identity",width=0.75)
C<- B+ geom_bar(aes(y=females),fill="red",stat="identity",width=0.75)
D<- C+coord_flip()
E<-D+ scale_y_continuous(breaks = seq(-600000, 600000, 200000),
labels = paste(as.character(c(seq(6, 0, -2),seq(2,6,2))), "x10^5"),
limits=c(-650000,650000))
F<-E+ xlab("Age") + ylab("Population number")
G<-F+ ggtitle(paste("Population Pyramid of Algeria:", year1)))
H<-G+ annotate('text', x = 95, y = 250000, label = 'Females', size = 5,
colour="red")
I<-H")+theme(plot.title = element_text(hjust = 0.5,size=12,face="bold"),
panel.border = element_rect(colour = "black",fill=NA,size=1), axis.text =
element_text(size=12,face="bold"))
print(H)
```

Figure 15: Population Pyramid



2.1.7 A little bit more

In order to change the background color from gray to white we just need to put:

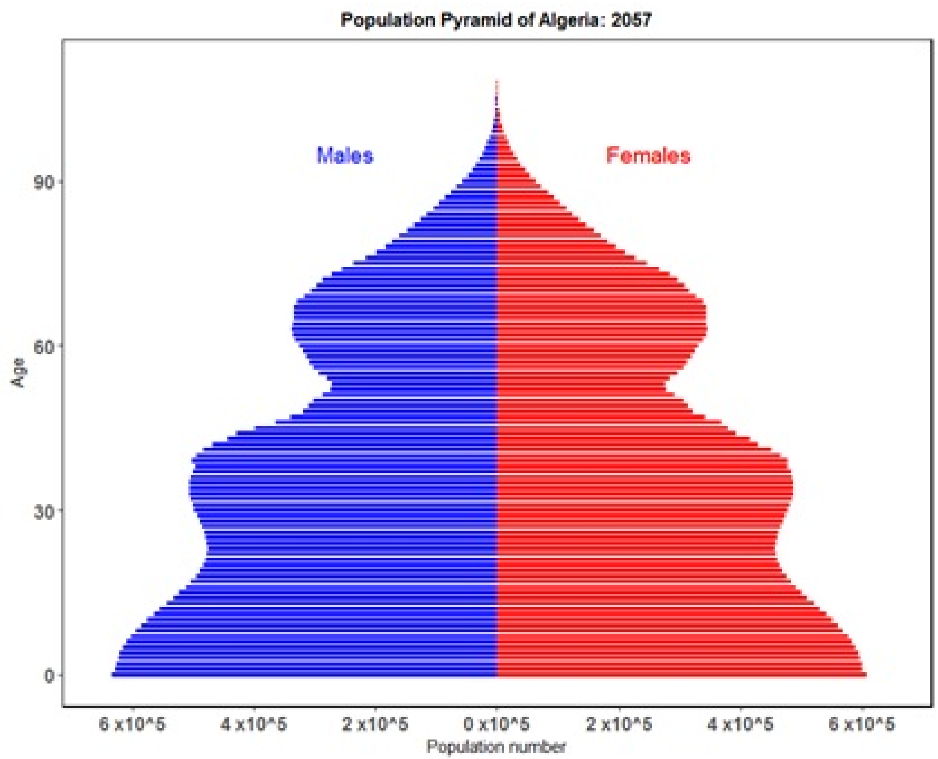
`panel.background = element_rect(fill=NA)` into `+theme()`

It makes :

```
i<-40
year1<-as.character(2015+i)
pyram<-cbind.data.frame(seq(0,110,1),-PopM[1:111,i],PopF[1:111,i])
colnames(pyram)<-c("age","males","females")
A<-ggplot(pyram, aes(x=age))
B<-A+ geom_bar(aes(y=males),fill="blue",stat="identity",width=0.75)
C<- B+ geom_bar(aes(y=females),fill="red",stat="identity",width=0.75)
D<- C+coord_flip()
E<-D+ scale_y_continuous(breaks = seq(-600000, 600000, 200000),
labels = paste(as.character(c(seq(6, 0, -2),seq(2,6,2))), "x10^5"),
limits=c(-650000,650000))
F<-E+ xlab("Age") + ylab("Population number")
G<-F+ ggtitle(paste("Population Pyramid of Algeria:", year1)))
H<-G+ annotate('text', x = 95, y = 250000, label = 'Females', size = 5,
```

```
colour="red")
I<-H+theme(plot.title = element_text(hjust = 0.5,size=12,face="bold"),
panel.border = element_rect(colour = "black",fill=NA,size=1), axis.text =
element_text(size=12,face="bold"), panel.background = element_rect(fill=
NA))
print(H)
```

Figure 16: Population Pyramid with white bakground



2.2 How to Make it moving moving ???

Required packages:

```
library(animation)
library(dplyr)
library(ggthemes)
```

The code to run:

```
saveGIF({
for (i in 1:56)
{
year1<-as.character(2014+i)
pyram<-cbind.data.frame(seq(0,110,1),-PopM[1:111,i],PopF[1:111,i])
```

```
colnames(pyram)<-c("age","males","females")
A<-ggplot(pyram,aes(x=age))+geom_bar(aes(y=males),fill="blue",stat=
"identity",width=0.75)+geom_bar(aes(y=females),fill="red",stat="identity",
width=0.75)+ coord_flip()+ scale_y_continuous(breaks= seq(-600000,600000,
200000), labels = paste(as.character(c(seq(6,0,-2),seq(2,6,2))),"x10^5"),
limits=c(-650000,650000))+xlab("Age")+ylab("Population number")+ggtitle(
paste("Population Pyramid of Algeria:", year1))+annotate('text', x=95, y=
250000,label='Females', size = 5,colour="red")+annotate('text', x=95, y=
250000, label='Females', size = 5, colour="red")+annotate('text', x=95,
y =-250000, label='Males', size = 5, colour="blue")+ theme(plot.title =
element_text(hjust = 0.5, size=12, face="bold"), panel.border =
element_rect(colour = "black", fill=NA,size=1),axis.text = element_text(
size=12, face="bold"))
print(A)
}}
, movie.name = 'pyram.gif', interval = 0.3, ani.width = 1100, ani.height
 = 820)
```

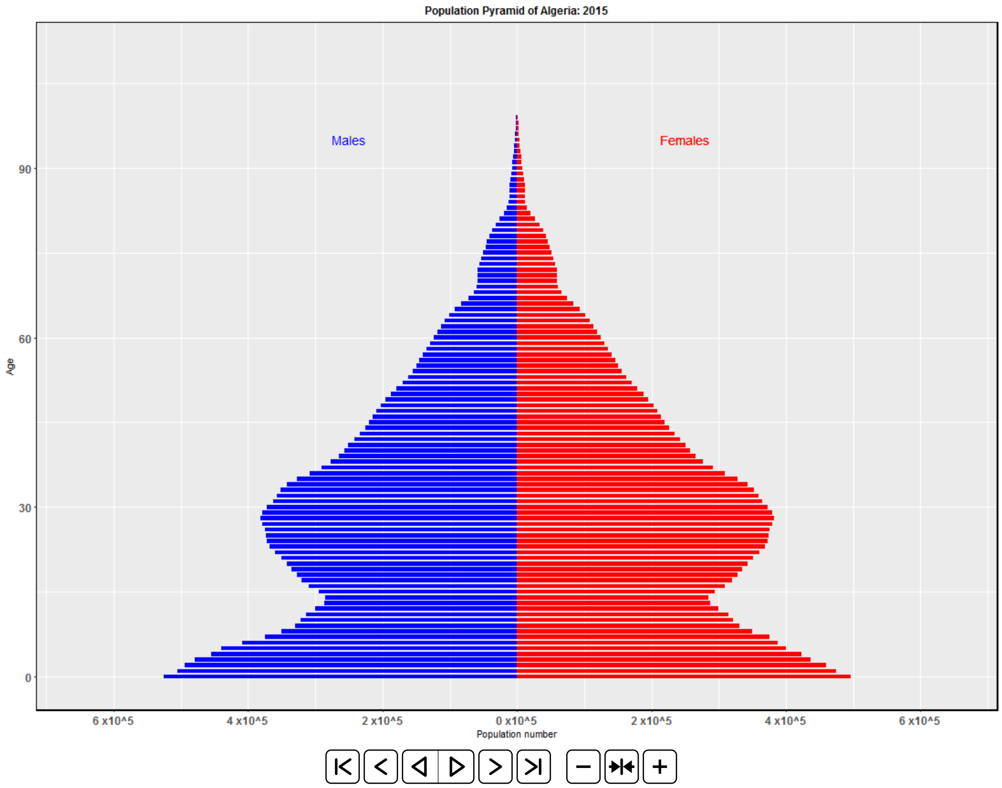
After having executed the R-code above, a message about the progression of the GIF creation is posted on the screen:

Figure 17: GIF creation message

```
Executing:
"convert -loop 0 -delay 30 Rplot1.png Rplot2.png Rplot3.png
    Rplot4.png Rplot5.png Rplot6.png Rplot7.png Rplot8.png
    Rplot9.png Rplot10.png Rplot11.png Rplot12.png Rplot13.png
    Rplot14.png Rplot15.png Rplot16.png Rplot17.png Rplot18.png
    Rplot19.png Rplot20.png Rplot21.png Rplot22.png Rplot23.png
    Rplot24.png Rplot25.png Rplot26.png Rplot27.png Rplot28.png
    Rplot29.png Rplot30.png Rplot31.png Rplot32.png Rplot33.png
    Rplot34.png Rplot35.png Rplot36.png Rplot37.png Rplot38.png
    Rplot39.png Rplot40.png Rplot41.png Rplot42.png Rplot43.png
    Rplot44.png Rplot45.png Rplot46.png Rplot47.png Rplot48.png
    Rplot49.png Rplot50.png Rplot51.png Rplot52.png Rplot53.png
    Rplot54.png Rplot55.png Rplot56.png "pyram.gif""
Output at: pyram.gif
[1] TRUE
>
```

Once you get this message, the gif file can be found in the same directory as the R-project location. To open it, you should use any internet browser or to put it on power point full screen.

Figure 18: Dynamic population pyramid



In order to visualize the dynamic pyramid, you can insert the GIF plot into a power point file and to make it on full screen view or you can just open the GIF using any internet browser.

Converter Error Message

Sometimes, when trying to run the code to create the GIF, an error message appears and it concerns the converter *ImageMagick*. This last is not a part of R, and i is only a graphical tools which allow the creation of a GIF correctely. What do you need to do in such a case, is to install ImageMagic version 7 or higher because the old versions work with converter.exe which is not adapted to the new versions of Rstudio. The right converter is magick . This application can be downloaded from:

`www.imagemagick.org/script/download.php`.

Then, you need to run the following code in R to update the location of the converter being installed:

`ani.options(convert = 'C:/PROGRA~1/ImageMagick-7.0.7-Q8/convert.exe')`

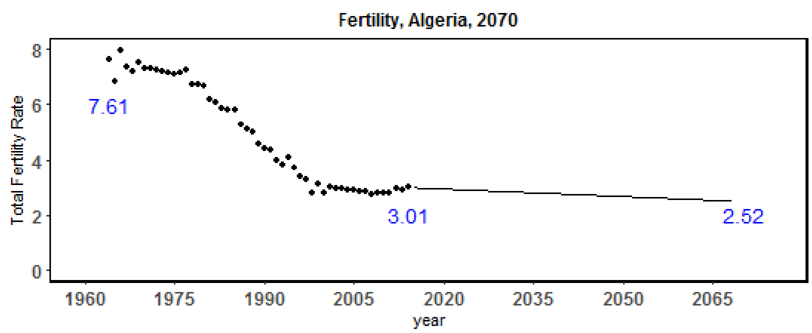
before to run again the `saveGIF()`

3 APPLICATION EXAMPLES

3.1 Dynamic Total Fertility Rate projection

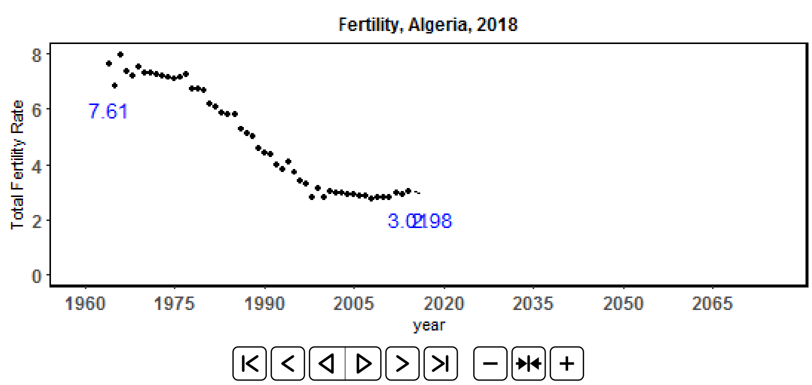
- Download historical and the projected series of life expectancy at birth for males and females in Algeria from : http://www.cread.dz/Actuarial_Demography/Donnees_Site/Total_Fertility_Rate.xlsx
- Using ggplot, try to perform a similar plot as

Figure 19: GIF creation message



- Make it moving as in the Figure bellow

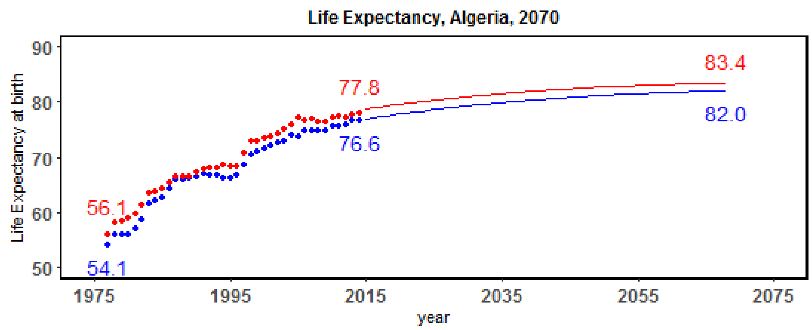
Figure 20: Dynamic Fertility rate projection



3.2 Dynamic life expectancy projection:

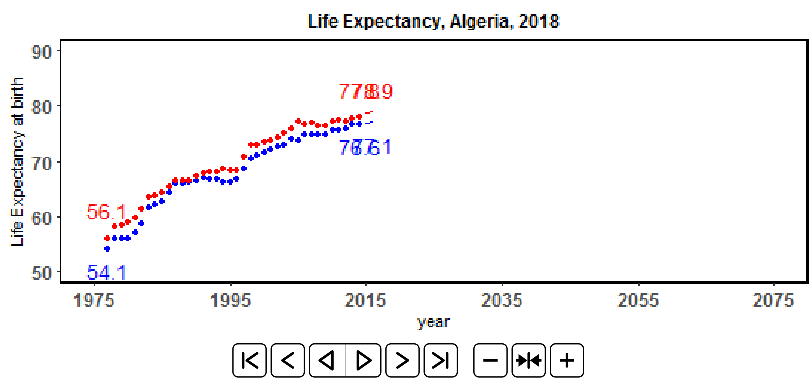
- Download historical and the projected series of life expectancy at birth for males and females in Algeria from : http://www.cread.dz/Actuarial_Demography/Donnees_Site/Life_exp_coherent_forecast.xlsx
- Using ggplot, try to perform a similar plot as

Figure 21: GIF creation message



- Make it moving as in Figure

Figure 22: Dynamic Fertility rate projection



4 REFERENCES

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- Flici, F. (2016b). Projection des taux de fécondité de la population algérienne á lhorizon 2050. MPRA Paper No. 99077, posted 12 Mar 2020. [https://mpra.ub.uni-muenchen.de/99077/1/MPRA_paper_99077.pdf]
- Flici, F. (2017). Longevity and pension plan sustainability in Algerie: Taking the re- tirees mortality experience into account. Doctoral dissertation, Higher National School of Statistics and Applied Economics (ENSSEA), Kolea, Algeria.
- Hyndman, R. J., Booth, H., & Yasmeen, F. (2013). Coherent mortality forecasting: the product-ratio method with functional time series models. *Demography, 50*(1), 261-283.
- Lee, R. D. (1993). Modeling and forecasting the time series of US fertility: Age distribution, range, and ultimate level. *International Journal of Forecasting, 9*(2), 187-202.