

# Build Dataset: Human migration dataset based on UN WPP and World Bank

Oscar A. Trevizo

2023-05-08

## Contents

<b>1</b>	<b>Introduction</b>	<b>3</b>
<b>2</b>	<b>Load the libraries</b>	<b>3</b>
<b>3</b>	<b>United Nations WPP</b>	<b>3</b>
3.1	Load the data . . . . .	3
3.2	Create WPP data set . . . . .	3
3.3	Add Columns Regions and Subregions . . . . .	10
3.4	Rename and re-sort columns . . . . .	11
3.4.1	Save column names and create a table . . . . .	11
3.4.2	Column definitions . . . . .	11
3.4.3	Rename wpp columns . . . . .	14
3.4.4	Re-sort the columns . . . . .	14
3.5	Column variable types . . . . .	15
3.6	Remove some columns . . . . .	15
3.7	Add columns . . . . .	16
3.7.1	Add migration stat variables . . . . .	16
3.7.2	Add columns with stats on migration . . . . .	16
3.7.3	Create factor variables for migration . . . . .	16
3.7.3.1	Create new factor variable: emigrates (1, 0) . . . . .	16
3.7.3.2	New columns migration pattern mig_pattern: factor ‘emigration’ or ‘immigration’ . . . . .	16
3.7.3.3	Create factor variable for migration_swings . . . . .	17

<b>4 World Bank</b>	<b>17</b>
4.1 DataBase . . . . .	18
4.2 World Development Indicators . . . . .	18
4.3 WorldBank databank report . . . . .	18
4.4 Load the data . . . . .	18
4.5 World Bank data set definitions . . . . .	18
4.6 Create WPP data set . . . . .	19
4.7 Rename columns . . . . .	19
4.7.1 Column definitions . . . . .	20
4.7.2 Rename columns . . . . .	21
4.8 Replace ‘.’ values with NA . . . . .	21
4.9 Coerce chars as numeric . . . . .	21
4.10 WB Summary . . . . .	22
4.11 Correlation pairs . . . . .	22
4.11.1 Economics indicators . . . . .	22
4.11.2 Development indicators . . . . .	23
4.12 Transforms . . . . .	24
4.13 Summary and correlation pairs of log transformed variables . . . . .	25
<b>5 Build the dataframe</b>	<b>28</b>
5.1 Join WPP with WB by ISO3 and Year . . . . .	28
5.2 Reorder the data set columns . . . . .	29
5.3 Column names wpp_wb . . . . .	29
5.4 Separate non-numeric from outcome and predictor variables . . . . .	29
5.5 Rearrange migration variables to the left of the numeric dataframe . . . . .	30
<b>6 Train test split</b>	<b>31</b>
6.1 Explore train and test sets . . . . .	31
6.1.1 By region . . . . .	32
6.1.2 By subregion . . . . .	32
6.1.3 By country . . . . .	33
6.1.4 By year . . . . .	34
6.1.5 Countries by region . . . . .	35
<b>7 Write to CSV to be used downstream</b>	<b>35</b>
<b>8 References</b>	<b>35</b>

# 1 Introduction

At the end of this use case, we will have a dataset built on sources from the United Nations and the World Bank to provide relationships between migration, demographics, socioeconomic, and development indicators.

## 2 Load the libraries

```
# Essential libraries
library(dplyr)
library(tidyr)
library(ggplot2)
library(psych)
library(GGally)
library(PerformanceAnalytics)
```

## 3 United Nations WPP

### 3.1 Load the data

```
# https://population.un.org/wpp/Download/Files/1_Indicators%20(Standard)/\
# EXCEL_FILES/1_General/WPP2022_GEN_F01_DEMOGRAPHIC_INDICATORS_REV1.xlsx
# wpp_raw <- read_excel('data/wpp.xlsx',
#                         sheet = 'Estimates',
#                         skip = 16,
#                         col_types = 'text')

# Saved as CSV
wpp_raw <- read.csv('../data/WPP2022_GEN_F01_DEMOGRAPHIC_INDICATORS_REV1.csv', check.names=FALSE)
```

### 3.2 Create WPP data set

```
# The first 3 columns listed below are only informative.
# Total population is redundant. Keeping the July data.
# Notice, Year is class 'int'
wpp <- wpp_raw %>% filter(Type == 'Country/Area') %>%
  dplyr::select(-c('Variant',
                 'Notes',
                 'Location code',
                 'SDMX code**',
                 'Total Population, as of 1 January (thousands)'))

dim(wpp)

## [1] 17064     60
```

```
head(wpp)
```

```
##   Index Region, subregion, country or area * ISO3 Alpha-code ISO2 Alpha-code
## 1  1733                      Burundi      BDI      BI
## 2  1734                      Burundi      BDI      BI
## 3  1735                      Burundi      BDI      BI
## 4  1736                      Burundi      BDI      BI
## 5  1737                      Burundi      BDI      BI
## 6  1738                      Burundi      BDI      BI
##           Type Parent code Year Total Population, as of 1 July (thousands)
## 1 Country/Area      910 1950                         2 254
## 2 Country/Area      910 1951                         2 303
## 3 Country/Area      910 1952                         2 352
## 4 Country/Area      910 1953                         2 399
## 5 Country/Area      910 1954                         2 447
## 6 Country/Area      910 1955                         2 495
##   Male Population, as of 1 July (thousands)
## 1                           1 080
## 2                           1 105
## 3                           1 129
## 4                           1 153
## 5                           1 177
## 6                           1 201
##   Female Population, as of 1 July (thousands)
## 1                           1 174
## 2                           1 199
## 3                           1 223
## 4                           1 246
## 5                           1 270
## 6                           1 294
##   Population Density, as of 1 July (persons per square km)
## 1                               86.9
## 2                               88.8
## 3                               90.6
## 4                               92.5
## 5                               94.3
## 6                               96.2
##   Population Sex Ratio, as of 1 July (males per 100 females)
## 1                               91.9
## 2                               92.1
## 3                               92.3
## 4                               92.5
## 5                               92.7
## 6                               92.8
##   Median Age, as of 1 July (years)
## 1                               18.3
## 2                               18.1
## 3                               17.9
## 4                               17.7
## 5                               17.5
## 6                               17.3
##   Natural Change, Births minus Deaths (thousands)
## 1                               63
```

## 2		62
## 3		62
## 4		62
## 5		63
## 6		63
## Rate of Natural Change (per 1,000 population)	Population Change (thousands)	
## 1	27.8	50
## 2	26.8	49
## 3	26.1	48
## 4	25.8	47
## 5	25.5	48
## 6	25.4	49
## Population Growth Rate (percentage)	Population Annual Doubling Time (years)	
## 1	2.20	31.5
## 2	2.11	32.8
## 3	2.04	34.0
## 4	1.97	35.2
## 5	1.97	35.3
## 6	1.96	35.4
## Births (thousands)	Births by women aged 15 to 19 (thousands)	
## 1	116	11
## 2	117	11
## 3	118	11
## 4	119	11
## 5	120	12
## 6	121	12
## Crude Birth Rate (births per 1,000 population)		
## 1	51.3	
## 2	50.7	
## 3	49.9	
## 4	49.4	
## 5	48.9	
## 6	48.4	
## Total Fertility Rate (live births per woman)		
## 1	6.92	
## 2	6.91	
## 3	6.90	
## 4	6.92	
## 5	6.92	
## 6	6.93	
## Net Reproduction Rate (surviving daughters per woman)		
## 1	2.05	
## 2	2.06	
## 3	2.06	
## 4	2.08	
## 5	2.09	
## 6	2.11	
## Mean Age Childbearing (years)		
## 1	31.0	
## 2	31.0	
## 3	31.0	
## 4	31.0	
## 5	31.0	
## 6	31.1	

```

## Sex Ratio at Birth (males per 100 female births) Total Deaths (thousands)
## 1 103 53
## 2 103 55
## 3 103 56
## 4 103 57
## 5 103 57
## 6 103 58
## Male Deaths (thousands) Female Deaths (thousands)
## 1 27 26
## 2 28 27
## 3 29 27
## 4 29 28
## 5 29 28
## 6 29 28
## Crude Death Rate (deaths per 1,000 population)
## 1 23.5
## 2 23.9
## 3 23.8
## 4 23.6
## 5 23.3
## 6 23.0
## Life Expectancy at Birth, both sexes (years)
## 1 40.6
## 2 40.8
## 3 41.0
## 4 41.3
## 5 41.6
## 6 41.9
## Male Life Expectancy at Birth (years) Female Life Expectancy at Birth (years)
## 1 39.2 41.9
## 2 39.3 42.2
## 3 39.6 42.4
## 4 39.9 42.6
## 5 40.1 43.0
## 6 40.4 43.3
## Life Expectancy at Age 15, both sexes (years)
## 1 44.9
## 2 45.1
## 3 45.1
## 4 45.2
## 5 45.3
## 6 45.5
## Male Life Expectancy at Age 15 (years)
## 1 43.7
## 2 43.7
## 3 43.8
## 4 43.9
## 5 44.0
## 6 44.1
## Female Life Expectancy at Age 15 (years)
## 1 46.0
## 2 46.3
## 3 46.3
## 4 46.4

```

```

## 5          46.5
## 6          46.7
## Life Expectancy at Age 65, both sexes (years)
## 1          11.0
## 2          11.1
## 3          11.1
## 4          11.1
## 5          11.2
## 6          11.2
## Male Life Expectancy at Age 65 (years)
## 1          10.6
## 2          10.6
## 3          10.6
## 4          10.7
## 5          10.7
## 6          10.7
## Female Life Expectancy at Age 65 (years)
## 1          11.4
## 2          11.5
## 3          11.5
## 4          11.5
## 5          11.6
## 6          11.6
## Life Expectancy at Age 80, both sexes (years)
## 1          4.7
## 2          4.8
## 3          4.8
## 4          4.8
## 5          4.8
## 6          4.8
## Male Life Expectancy at Age 80 (years)
## 1          4.5
## 2          4.5
## 3          4.5
## 4          4.5
## 5          4.5
## 6          4.5
## Female Life Expectancy at Age 80 (years)
## 1          4.9
## 2          5.0
## 3          5.0
## 4          5.0
## 5          5.0
## 6          5.0
## Infant Deaths, under age 1 (thousands)
## 1          18
## 2          19
## 3          19
## 4          19
## 5          19
## 6          19
## Infant Mortality Rate (infant deaths per 1,000 live births)
## 1          166.9
## 2          166.0

```

## 3	164.0
## 4	162.0
## 5	160.1
## 6	158.2
## Live Births Surviving to Age 1 (thousands)	
## 1	103.226
## 2	104.050
## 3	104.832
## 4	106.093
## 5	107.102
## 6	108.288
## Under-Five Deaths, under age 5 (thousands)	
## 1	29
## 2	31
## 3	31
## 4	32
## 5	32
## 6	32
## Under-Five Mortality (deaths under age 5 per 1,000 live births)	
## 1	283
## 2	281
## 3	278
## 4	274
## 5	271
## 6	268
## Mortality before Age 40, both sexes (deaths under age 40 per 1,000 live births)	
## 1	463
## 2	459
## 3	457
## 4	453
## 5	449
## 6	446
## Male Mortality before Age 40 (deaths under age 40 per 1,000 male live births)	
## 1	476
## 2	475
## 3	472
## 4	468
## 5	464
## 6	461
## Female Mortality before Age 40 (deaths under age 40 per 1,000 female live births)	
## 1	450
## 2	445
## 3	443
## 4	439
## 5	435
## 6	431
## Mortality before Age 60, both sexes (deaths under age 60 per 1,000 live births)	
## 1	618
## 2	614
## 3	612
## 4	609
## 5	605
## 6	601
## Male Mortality before Age 60 (deaths under age 60 per 1,000 male live births)	

```

## 1          642
## 2          641
## 3          638
## 4          635
## 5          632
## 6          628
##   Female Mortality before Age 60 (deaths under age 60 per 1,000 female live births)
## 1          595
## 2          589
## 3          588
## 4          584
## 5          580
## 6          576
##   Mortality between Age 15 and 50, both sexes (deaths under age 50 per 1,000 alive at age 15)
## 1          291
## 2          288
## 3          288
## 4          286
## 5          284
## 6          282
##   Male Mortality between Age 15 and 50 (deaths under age 50 per 1,000 males alive at age 15)
## 1          308
## 2          308
## 3          307
## 4          305
## 5          304
## 6          301
##   Female Mortality between Age 15 and 50 (deaths under age 50 per 1,000 females alive at age 15)
## 1          275
## 2          270
## 3          271
## 4          269
## 5          266
## 6          264
##   Mortality between Age 15 and 60, both sexes (deaths under age 60 per 1,000 alive at age 15)
## 1          424
## 2          421
## 3          420
## 4          418
## 5          416
## 6          413
##   Male Mortality between Age 15 and 60 (deaths under age 60 per 1,000 males alive at age 15)
## 1          453
## 2          452
## 3          451
## 4          449
## 5          447
## 6          444
##   Female Mortality between Age 15 and 60 (deaths under age 60 per 1,000 females alive at age 15)
## 1          398
## 2          392
## 3          392
## 4          390
## 5          387

```

```

## 6
## Net Number of Migrants (thousands) Net Migration Rate (per 1,000 population)
## 1 - 13 -5.9
## 2 - 13 -5.7
## 3 - 14 -5.8
## 4 - 15 -6.2
## 5 - 15 -5.9
## 6 - 15 -5.9

```

384

### 3.3 Add Columns Regions and Subregions

```

# Get Subregions in a small table.... One year takes care of having one row per region.
# We need to include both Subregion and Region because the USA, Canada, Greenland, ...
# have NORTH AMERICA as Parent Code while the other countries have Subregion as
# Parent Code. Pick one year, any year like 2019 to create these temporary dataframe.
wpp_parent_code <- wpp_raw %>% filter((Type == 'Subregion' | Type == 'Region')
                                         & Year == 2019) %>%
  dplyr::select(c('Region', subregion, country or area *,
                 'Location code'))

# Rename columns in preparation for a merge that will be done based on 'Parent code'
colnames(wpp_parent_code) <- c('Subregion', 'Parent code')

# Now merge with wpp based on 'Parent code'
wpp <- wpp %>% left_join(wpp_parent_code)

# Now we have subregions.
# The next step is to add Region (COninent / subcontinent). The problem there
# is NORTH AMERICA is Region but also Parent Code for USA and Canada.

wpp_subregions <- wpp_raw %>% filter(Type == 'Subregion'
                                         & Year == 2019) %>%
  dplyr::select(c('Region', subregion, country or area *,
                 'Parent code'))

wpp_regions <- wpp_raw %>% filter(Type == 'Region'
                                       & Year == 2019) %>%
  dplyr::select(c('Region', subregion, country or area *,
                 'Location code'))

# Rename columns in wpp_regions to match the column name 'Parent code'
# before left_join(). this way the function automatically will pick Parent code

colnames(wpp_regions) <- c('Region', 'Parent code')
colnames(wpp_subregions) <- c('Subregion', 'Parent code')

# now the join will automatically use 'Parent code' to join left.
wpp_subregions <- wpp_subregions %>% left_join(wpp_regions)

# Remove columns 'Parent Code' no longer needed
wpp_subregions <- wpp_subregions %>% dplyr::select(-c('Parent code'))

```

```

# But we need to add NORTH AMERICA... Let's follow the Upper Case Lower Case approach
wpp_subregions <- rbind(wpp_subregions, c('NORTHERN AMERICA', 'NORTHERN AMERICA'))

# Now merge with wpp based on 'Subregion'
wpp <- wpp %>% left_join(wpp_subregions)

```

## 3.4 Rename and re-sort columns

### 3.4.1 Save column names and create a table

```

wpp_columns_orig <- colnames(wpp)
wpp_columns_new <- c('index', 'country', 'ISO3', 'ISO2', 'type', 'parent_code', 'year',
                      'pop', 'pop_m', 'pop_f', 'pop_density', 'pop_sex_ratio', 'med_age',
                      'natural_change', 'natural_change_rate', 'pop_change',
                      'pop_growth_rate', 'pop_doubling', 'births', 'births_w15to19',
                      'birth_rate', 'fertility_rate', 'net_reproduction_rate',
                      'mean_age_childbearing', 'sex_ratio_birth', 'tot_deaths',
                      'male_deaths', 'female_deaths', 'death_rate',
                      'life_exp', 'life_exp_m', 'life_exp_f',
                      'life_exp_15', 'life_exp_15_m', 'life_exp_15_f',
                      'life_exp_65', 'life_exp_65_m', 'life_exp_65_f',
                      'life_exp_80', 'life_exp_80_m', 'life_exp_80_f',
                      'infant_deaths', 'under_five_mortality',
                      'live_births', 'deaths_under_5', 'mortality_rate_under_5',
                      'mortality_40', 'mortality_40_m', 'mortality_40_f',
                      'mortality_60', 'mortality_60_m', 'mortality_60_f',
                      'mortality_15_50', 'mortality_15_50_m', 'mortality_15_50_f',
                      'mortality_15_60', 'mortality_15_60_m', 'mortality_15_60_f',
                      'net_migrants', 'net_mig_rate', 'subregion', 'region'
)

```

### 3.4.2 Column definitions

```

wpp_columns_table <- data.frame(wpp_columns_orig, wpp_columns_new)
wpp_columns_table

```

##	wpp_columns_orig
## 1	Index
## 2	Region, subregion, country or area *
## 3	ISO3 Alpha-code
## 4	ISO2 Alpha-code
## 5	Type
## 6	Parent code
## 7	Year
## 8	Total Population, as of 1 July (thousands)
## 9	Male Population, as of 1 July (thousands)
## 10	Female Population, as of 1 July (thousands)
## 11	Population Density, as of 1 July (persons per square km)

```

## 12 Population Sex Ratio, as of 1 July (males per 100 females)
## 13 Median Age, as of 1 July (years)
## 14 Natural Change, Births minus Deaths (thousands)
## 15 Rate of Natural Change (per 1,000 population)
## 16 Population Change (thousands)
## 17 Population Growth Rate (percentage)
## 18 Population Annual Doubling Time (years)
## 19 Births (thousands)
## 20 Births by women aged 15 to 19 (thousands)
## 21 Crude Birth Rate (births per 1,000 population)
## 22 Total Fertility Rate (live births per woman)
## 23 Net Reproduction Rate (surviving daughters per woman)
## 24 Mean Age Childbearing (years)
## 25 Sex Ratio at Birth (males per 100 female births)
## 26 Total Deaths (thousands)
## 27 Male Deaths (thousands)
## 28 Female Deaths (thousands)
## 29 Crude Death Rate (deaths per 1,000 population)
## 30 Life Expectancy at Birth, both sexes (years)
## 31 Male Life Expectancy at Birth (years)
## 32 Female Life Expectancy at Birth (years)
## 33 Life Expectancy at Age 15, both sexes (years)
## 34 Male Life Expectancy at Age 15 (years)
## 35 Female Life Expectancy at Age 15 (years)
## 36 Life Expectancy at Age 65, both sexes (years)
## 37 Male Life Expectancy at Age 65 (years)
## 38 Female Life Expectancy at Age 65 (years)
## 39 Life Expectancy at Age 80, both sexes (years)
## 40 Male Life Expectancy at Age 80 (years)
## 41 Female Life Expectancy at Age 80 (years)
## 42 Infant Deaths, under age 1 (thousands)
## 43 Infant Mortality Rate (infant deaths per 1,000 live births)
## 44 Live Births Surviving to Age 1 (thousands)
## 45 Under-Five Deaths, under age 5 (thousands)
## 46 Under-Five Mortality (deaths under age 5 per 1,000 live births)
## 47 Mortality before Age 40, both sexes (deaths under age 40 per 1,000 live births)
## 48 Male Mortality before Age 40 (deaths under age 40 per 1,000 male live births)
## 49 Female Mortality before Age 40 (deaths under age 40 per 1,000 female live births)
## 50 Mortality before Age 60, both sexes (deaths under age 60 per 1,000 live births)
## 51 Male Mortality before Age 60 (deaths under age 60 per 1,000 male live births)
## 52 Female Mortality before Age 60 (deaths under age 60 per 1,000 female live births)
## 53 Mortality between Age 15 and 50, both sexes (deaths under age 50 per 1,000 alive at age 15)
## 54 Male Mortality between Age 15 and 50 (deaths under age 50 per 1,000 males alive at age 15)
## 55 Female Mortality between Age 15 and 50 (deaths under age 50 per 1,000 females alive at age 15)
## 56 Mortality between Age 15 and 60, both sexes (deaths under age 60 per 1,000 alive at age 15)
## 57 Male Mortality between Age 15 and 60 (deaths under age 60 per 1,000 males alive at age 15)
## 58 Female Mortality between Age 15 and 60 (deaths under age 60 per 1,000 females alive at age 15)
## 59 Net Number of Migrants (thousands)
## 60 Net Migration Rate (per 1,000 population)
## 61 Subregion
## 62 Region
## wpp_columns_new
## 1 index
## 2 country

```

```

## 3           ISO3
## 4           ISO2
## 5           type
## 6           parent_code
## 7           year
## 8           pop
## 9           pop_m
## 10          pop_f
## 11          pop_density
## 12          pop_sex_ratio
## 13          med_age
## 14          natural_change
## 15          natural_change_rate
## 16          pop_change
## 17          pop_growth_rate
## 18          pop_doubling
## 19          births
## 20          births_w15to19
## 21          birth_rate
## 22          fertility_rate
## 23          net_reproduction_rate
## 24          mean_age_childbearing
## 25          sex_ratio_birth
## 26          tot_deaths
## 27          male_deaths
## 28          female_deaths
## 29          death_rate
## 30          life_exp
## 31          life_exp_m
## 32          life_exp_f
## 33          life_exp_15
## 34          life_exp_15_m
## 35          life_exp_15_f
## 36          life_exp_65
## 37          life_exp_65_m
## 38          life_exp_65_f
## 39          life_exp_80
## 40          life_exp_80_m
## 41          life_exp_80_f
## 42          infant_deaths
## 43          under_five_mortality
## 44          live_births
## 45          deaths_under_5
## 46 mortality_rate_under_5
## 47          mortality_40
## 48          mortality_40_m
## 49          mortality_40_f
## 50          mortality_60
## 51          mortality_60_m
## 52          mortality_60_f
## 53          mortality_15_50
## 54          mortality_15_50_m
## 55          mortality_15_50_f
## 56          mortality_15_60

```

```

## 57      mortality_15_60_m
## 58      mortality_15_60_f
## 59          net_migrants
## 60          net_mig_rate
## 61          subregion
## 62          region

```

### 3.4.3 Rename wpp columns

```

# Rename dataframe columns
(colnames(wpp) <- wpp_columns_new)

## [1] "index"                  "country"                 "ISO3"
## [4] "IS02"                   "type"                    "parent_code"
## [7] "year"                    "pop"                     "pop_m"
## [10] "pop_f"                  "pop_density"              "pop_sex_ratio"
## [13] "med_age"                "natural_change"          "natural_change_rate"
## [16] "pop_change"              "pop_growth_rate"         "pop_doubling"
## [19] "births"                  "births_w15to19"           "birth_rate"
## [22] "fertility_rate"         "net_reproduction_rate"   "mean_age_childbearing"
## [25] "sex_ratio_birth"        "tot_deaths"               "male_deaths"
## [28] "female_deaths"          "death_rate"               "life_exp"
## [31] "life_exp_m"              "life_exp_f"                "life_exp_15"
## [34] "life_exp_15_m"           "life_exp_15_f"             "life_exp_65"
## [37] "life_exp_65_m"           "life_exp_65_f"             "life_exp_80"
## [40] "life_exp_80_m"           "life_exp_80_f"              "infant_deaths"
## [43] "under_five_mortality"    "live_births"               "deaths_under_5"
## [46] "mortality_rate_under_5"   "mortality_40"               "mortality_40_m"
## [49] "mortality_40_f"           "mortality_60"               "mortality_60_m"
## [52] "mortality_60_f"           "mortality_15_50"              "mortality_15_50_m"
## [55] "mortality_15_50_f"         "mortality_15_60"              "mortality_15_60_m"
## [58] "mortality_15_60_f"         "net_migrants"              "net_mig_rate"
## [61] "subregion"                "region"

```

### 3.4.4 Re-sort the columns

```

# Obtain numeric columns
col_numeric <- wpp_columns_new[7:60]

# Obtain non-numeric, character, columns... It is a handful, sort it here by hand
col_char <- c('index', 'country', 'subregion', 'region',
            'ISO3', 'IS02', 'type', 'parent_code')

wpp <- wpp %>% dplyr::select(col_char, col_numeric)

colnames(wpp)

## [1] "index"                  "country"                 "subregion"
## [4] "region"                  "ISO3"                    "IS02"
## [7] "type"                   "parent_code"              "year"

```

```

## [10] "pop"                      "pop_m"                  "pop_f"
## [13] "pop_density"                "pop_sex_ratio"          "med_age"
## [16] "natural_change"              "natural_change_rate"    "pop_change"
## [19] "pop_growth_rate"             "pop_doubling"           "births"
## [22] "births_w15to19"              "birth_rate"              "fertility_rate"
## [25] "net_reproduction_rate"       "mean_age_childbearing" "sex_ratio_birth"
## [28] "tot_deaths"                 "male_deaths"            "female_deaths"
## [31] "death_rate"                 "life_exp"                "life_exp_m"
## [34] "life_exp_f"                 "life_exp_15"              "life_exp_15_m"
## [37] "life_exp_15_f"               "life_exp_65"              "life_exp_65_m"
## [40] "life_exp_65_f"               "life_exp_80"              "life_exp_80_m"
## [43] "life_exp_80_f"               "infant_deaths"          "under_five_mortality"
## [46] "live_births"                 "deaths_under_5"          "mortality_rate_under_5"
## [49] "mortality_40"                "mortality_40_m"          "mortality_40_f"
## [52] "mortality_60"                "mortality_60_m"          "mortality_60_f"
## [55] "mortality_15_50"              "mortality_15_50_m"        "mortality_15_50_f"
## [58] "mortality_15_60"              "mortality_15_60_m"        "mortality_15_60_f"
## [61] "net_migrants"                "net_mig_rate"

```

### 3.5 Column variable types

Now we need to make numeric columns be type numeric.

```

# Remove white spaces from numeric columns
# https://www.geeksforgeeks.org/remove-all-whitespace-in-each-dataframe-column-in-r/
wpp[, 9:62] <- as.data.frame(apply(wpp[, 9:62], 2, function(x) gsub("\\s+", "", x)))

# Coerce numeric
# Tips from:
# https://stackoverflow.com/questions/2288485/how-to-convert-a-data-frame-column-to-numeric-type
wpp[, 9:62] <- sapply(wpp[, 9:62], as.numeric)

# Year should actually be Date as this:
# The challenge with a Date is it will try to pin down the exact month and day too.
# Even if the format is Year only, underneath the data will have exact days
# wpp$Year <- as.Date(wpp$year, '%Y')

# But for now, leave it as numeric for simplicity.
wpp$year <- as.numeric(wpp$year)

# Remove columns 'type' and 'parent_code' no longer needed
wpp <- wpp %>% dplyr::select(-c('type', 'parent_code'))

```

### 3.6 Remove some columns

```

# Remove pop_doubling and live_births columns, which have NAs
wpp <- wpp %>% dplyr::select(-c('pop_doubling', 'live_births'))

```

## 3.7 Add columns

### 3.7.1 Add migration stat variables

Describe stats for migration

```
describe(wpp[,c("net_migrants", "net_mig_rate")])
```

##	vars	n	mean	sd	median	trimmed	mad	min	max	range	
##	net_migrants	1	16992	-0.01	126.75	0.0	-2.16	8.90	-2290.0	1867.0	4157.0
##	net_mig_rate	2	16992	-0.05	16.51	-0.4	-0.67	4.74	-526.3	415.2	941.5
##			skew	kurtosis	se						
##	net_migrants	0.52	90.16	0.97							
##	net_mig_rate	0.40	125.05	0.13							

### 3.7.2 Add columns with stats on migration

```
# Use dplyr to find mu, sigma, and quantiles

wpp_mig_stats <- wpp %>% group_by(ISO3) %>%
  summarise(net_mig_rate_mean = mean(net_mig_rate, na.rm = TRUE),
            net_mig_rate_sd = sd(net_mig_rate, na.rm = TRUE),
            net_mig_rate_med = median(net_mig_rate, na.rm = TRUE),
            net_mig_rate_25qtl = quantile(net_mig_rate, probs = 0.25, na.rm = TRUE),
            net_mig_rate_75qtl = quantile(net_mig_rate, probs = 0.75, na.rm = TRUE)
  )

# Now join those values to the data set.
wpp <- wpp %>% left_join(wpp_mig_stats)
```

### 3.7.3 Create factor variables for migration

**3.7.3.1 Create new factor variable: emigrates (1, 0)** This new column will have a 1 if the country emigrates (leaves), and a 0 where they don't migrate in net figures.

Call it emigrates. Gets a 1 if it has a negative migration. That is, more people emigrate (like Mexico). Gets a 0 if it has a positive or zero migration. That is, they experience immigration (like the US).

That is, if it has a negative net\_migration, the country emigrates (leaves), and if it has a positive net\_migration, the country receives migrants.

**3.7.3.2 New columns migration pattern mig\_pattern: factor ‘emigration’ or ‘immigration’**  
Countries may experience a mix of years when they have emigration (leaving) and other years when they have immigration. For the most part the pattern is consistent. Some countries consistently receive immigrants (like the United States and Germany) and other countries consistently have emigrants leave the country.

To avoid a possible mix between emigration and immigration within a country, this variable will classify the country based on its general pattern. The variable will be class as factor and will have the values:

- emigration
- immigration

To add this column we need to go through a two step process.

```
# First remove any country that has NA in net_mig_rate.  
# Upon exploration, there is only one country as such = VAT (the Vatican)  
# It is best to remove it as it does not show any other patterns.  
# (note, there was another command before that removed the Vatican)  
# (leave this one here for now, even though it is not doing anything)  
wpp <- wpp %>% drop_na(net_mig_rate)  
  
# This command create the new column 'emigrates' with values either 1 or 0.  
# Note that the same country may have a mix of 1s and 0s in different years.  
# This variable can change from 1 to 0 or 0 1 for a country from year to year  
wpp <- wpp %>% mutate(emigrates = ifelse(net_mig_rate < 0, 1, 0))  
  
# Mig patterns is a category. We want to assign a category to the country based on an  
# overall migration pattern over the years.  
# Emigration means the country tends to have emigrants (a negative mig rate overall),  
# while immigration means the country tends to receive migrants (a positive mig rate).  
# We will leave 0 as immigration to avoid having three categories.  
# But there was no single country with an exact 0.0000 mig rate mean.  
mig_pattern_df <- wpp %>% group_by(ISO3) %>%  
  summarise(mig_pattern = ifelse(median(net_mig_rate, na.rm = TRUE) > 0,  
                                 'immigration', 'emigration'))  
  
# Now join that pattern grouped by ISO3 (country) with the overall data set wpp  
wpp <- wpp %>% left_join(mig_pattern_df)
```

**3.7.3.3 Create factor variable for migration\_swings** Some countries exhibit swings, seasonal patterns (e.g. Qatar), while other countries exhibit a controlled migration pattern. That question can be explored by adding three additional columns to our data set, focusing on migration rate:

If a country exhibits swings between the 25 and 75 quantiles from negative to positive migration, the country needs to be identified as one that exhibits migration swings. Those countries could have seasonal migration, leaving the country and then entering the country again. That is a special category.

```
wpp <- wpp %>% mutate(migration_swings = ifelse(net_mig_rate_75qtl * net_mig_rate_25qtl < 0, 1, 0))  
  
wpp_mig_stats_swings <- wpp_mig_stats %>%  
  mutate(migration_swings = ifelse(net_mig_rate_75qtl * net_mig_rate_25qtl < 0, 1, 0))  
  
table(wpp_mig_stats_swings$migration_swings)  
  
##  
##    0    1  
## 132 104
```

## 4 World Bank

<https://www.worldbank.org/en/home>

## 4.1 DataBase

<https://databank.worldbank.org/>

- World Development Indicators
- Statistical Capacity Indicators
- Education Statistics
- Gender Statistics
- Health Nutrition and Population Statistics

## 4.2 World Development Indicators

Tool to select multitude variables to characterize countries or regions. It allows us to create custom report. The reports can be shared or can be private.

There are 1442 *Series* (i.e., variables, predictors) available.

## 4.3 WorldBank databank report

The tool allows you to select a layout, save the report and share the report. I created a shared report from WorldBank databank:

<https://databank.worldbank.org/Countries-GDP-and-Inflation/id/4f7a6fed>

## 4.4 Load the data

```
# From WOrld bankd O Databank:  
# https://databank.worldbank.org/id/49085302?Report_Name=Countries-GDP-Inflation-and-predictors&l=en  
# https://databank.worldbank.org/Countries-GDP-Inflation-and-predictors/id/18e02f13  
# Saved as CSV for convenience.  
#  
# wb_raw <- read.csv('data/wb.csv', check.names=FALSE, colClasses = 'character')  
wb_raw <- read.csv('../data/wb_2023.Q1.csv', check.names=FALSE)  
  
wb_metadata <- read.csv('../data/wb_metadata_2023.Q1.csv', check.names=FALSE, colClasses = 'character')
```

## 4.5 World Bank data set definitions

- From WB metadata

```
wb_metadata[,c('Indicator Name', 'Long definition')]
```

```
##                                     Indicator Name  
## 1                               GDP (current US$)  
## 2                           GDP growth (annual %)  
## 3                         GDP per capita (current US$)  
## 4      GDP per capita, PPP (current international $)  
## 5           Inflation, consumer prices (annual %)  
## 6 Adjusted net national income per capita (current US$)
```

```

## 7           Consumer price index (2010 = 100)
## 8           Food production index (2014-2016 = 100)
## 9           Intentional homicides (per 100,000 people)
## 10          Access to electricity (% of population)
## 11          CO2 emissions (metric tons per capita)
## 12          Compulsory education, duration (years)
## 13          International migrant stock (% of population)
## 14          International migrant stock, total
## 15          Net migration
##
## 1
## 2
## 3
## 4
## 5
## 6
## 7
## 8
## 9
## 10
## 11
## 12
## 13 International migrant stock is the number of people born in a country other than that in which they
## 14 International migrant stock is the number of people born in a country other than that in which they
## 15

```

## 4.6 Create WPP data set

```

# Use dplyr select() for simplicity. Put it in a new data frame wb.
# Notice Time is class 'int'... That is how read.csv pulled it in.
wb <- wb_raw %>% dplyr::select(-c('Country Name', 'Time Code',
                                    'International migrant stock (% of population) [SM.POP.TOTL.ZS]',
                                    'Net migration [SM.POP.NETM]'))

```

## 4.7 Rename columns

Anticipating a merge between the data sets from the World Bank (economics) with the United Nations (demographics), rename variables in the *wb* data set to match columns in the *wpp* data set. Specifically:

- ISO3: Country code
- Year: The time period.

Simultaneously, rename the remaining columns to something more practical from the scripting perspective. Save the old names and the new names in a new table for the record.

```

wb_columns_orig <- colnames(wb)
wb_columns_new <- c('ISO3',
                     'year',
                     'GDP',
                     'GDP_growth',

```

```

'GDP_pc',
'GDP_pc_ppp',
'inflation',
'natl_income_pc',
'cpi',
'food',
'homicides',
'electricity',
'co2_emissions',
'education',
'mig_stock'
)
)
```

#### 4.7.1 Column definitions

```
wb_columns_table <- data.frame(wb_columns_orig, wb_columns_new)
```

```
wb_columns_table
```

	wb_columns_orig
## 1	Country Code
## 2	Time
## 3	GDP (current US\$) [NY.GDP.MKTP.CD]
## 4	GDP growth (annual %) [NY.GDP.MKTP.KD.ZG]
## 5	GDP per capita (current US\$) [NY.GDP.PCAP.CD]
## 6	GDP per capita, PPP (current international \$) [NY.GDP.PCAP.PP.CD]
## 7	Inflation, consumer prices (annual %) [FP.CPI.TOTL.ZG]
## 8	Adjusted net national income per capita (current US\$) [NY.ADJ.NNTY.PC.CD]
## 9	Consumer price index (2010 = 100) [FP.CPI.TOTL]
## 10	Food production index (2014-2016 = 100) [AG.PRD.FOOD.XD]
## 11	Intentional homicides (per 100,000 people) [VC.IHR.PSRC.P5]
## 12	Access to electricity (% of population) [EG.ELC.ACCTS.ZS]
## 13	CO2 emissions (metric tons per capita) [EN.ATM.CO2E.PC]
## 14	Compulsory education, duration (years) [SE.COM.DURS]
## 15	International migrant stock, total [SM.POP.TOTL]
## wb_columns_new	
## 1	IS03
## 2	year
## 3	GDP
## 4	GDP_growth
## 5	GDP_pc
## 6	GDP_pc_ppp
## 7	inflation
## 8	natl_income_pc
## 9	cpi
## 10	food
## 11	homicides
## 12	electricity
## 13	co2_emissions
## 14	education
## 15	mig_stock

#### 4.7.2 Rename columns

```
(colnames(wb) <- wb_columns_new)

## [1] "IS03"           "year"            "GDP"             "GDP_growth"
## [5] "GDP_pc"         "GDP_pc_ppp"      "inflation"       "natl_income_pc"
## [9] "cpi"             "food"            "homicides"       "electricity"
## [13] "co2_emissions"  "education"       "mig_stock"

# head(wb)
```

#### 4.8 Replace '..' values with NA

```
# Replace across the entire data set, all columns, specifically applies to numerics.
wb[wb == '..'] <- NA
head(wb)

##   IS03 year      GDP GDP_growth      GDP_pc GDP_pc_ppp inflation
## 1 AFG 1960 537777811.111111 <NA> 62.3693745050559 <NA> <NA>
## 2 AFG 1961 548888895.555556 <NA> 62.4437034626929 <NA> <NA>
## 3 AFG 1962 546666677.777778 <NA> 60.9503638210144 <NA> <NA>
## 4 AFG 1963 751111191.111111 <NA> 82.0217375781519 <NA> <NA>
## 5 AFG 1964 800000044.444444 <NA> 85.5110734102311 <NA> <NA>
## 6 AFG 1965 1006666637.777778 <NA> 105.243195716467 <NA> <NA>
##   natl_income_pc cpi food homicides electricity co2_emissions education
## 1 <NA> <NA> <NA> <NA> <NA> <NA>
## 2 <NA> <NA> 41.48 <NA> <NA> <NA> <NA>
## 3 <NA> <NA> 41.81 <NA> <NA> <NA> <NA>
## 4 <NA> <NA> 41.62 <NA> <NA> <NA> <NA>
## 5 <NA> <NA> 45.13 <NA> <NA> <NA> <NA>
## 6 <NA> <NA> 47.24 <NA> <NA> <NA> <NA>
##   mig_stock
## 1 46468
## 2 <NA>
## 3 <NA>
## 4 <NA>
## 5 <NA>
## 6 49535
```

#### 4.9 Coerce chars as numeric

```
# Remove white spaces from numeric columns
# https://www.geeksforgeeks.org/remove-all-whitespace-in-each-dataframe-column-in-r/
wb[, 3:15] <- as.data.frame(apply(wb[, 3:15], 2, function(x) gsub("\\s+", "", x)))

wb[, 3:15] <- sapply(wb[, 3:15], as.numeric)

# Year should actually be Date:
```

```

# The challenge with a Date is it will try to pin down the exact month and day too.
# Even if the format is Year only, underneath the data will have exact days
# wb$year <- as.Date(wb$year, '%Y')

# But for now, leave it as numeric for simplicity.
wb$year <- as.numeric(wb$year)

```

## 4.10 WB Summary

```

# It's helpful to see the min and max in determining which variables are candidates for log transformation
summary(wb)

```

```

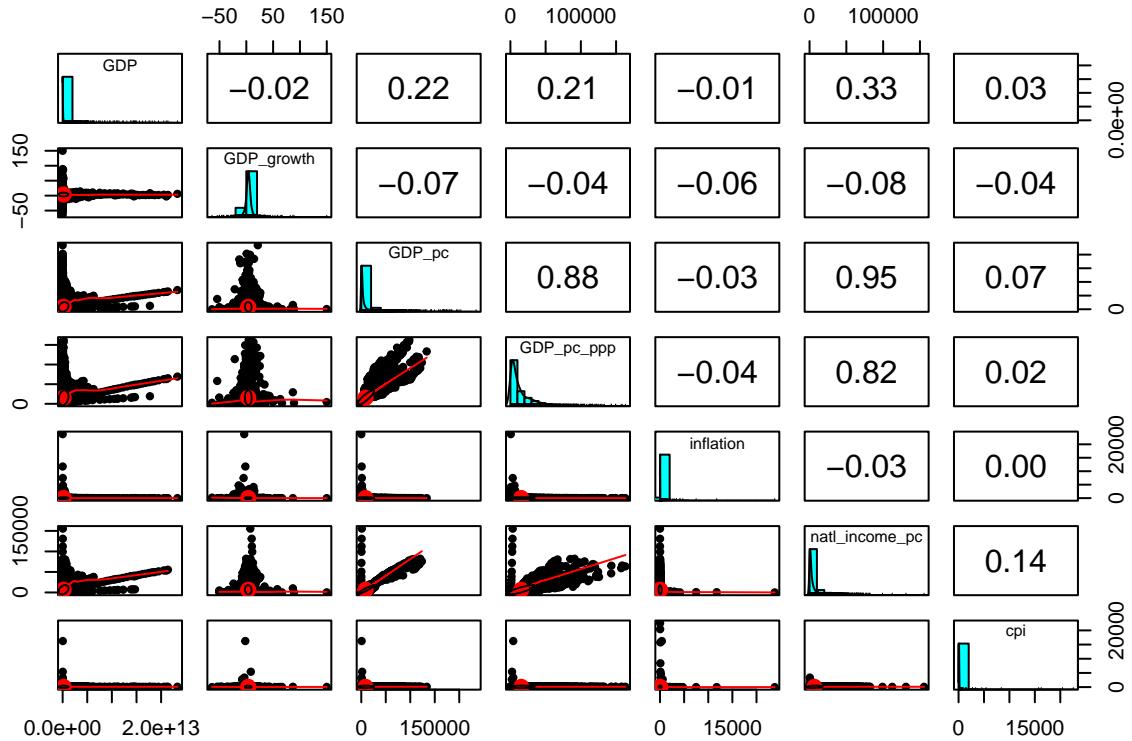
##      IS03            year          GDP          GDP_growth
##  Length:12591   Min.   :1960   Min.   :8.824e+06   Min.   :-64.047
##  Class :character 1st Qu.:1975   1st Qu.:1.577e+09   1st Qu.: 1.248
##  Mode  :character Median :1990   Median :8.350e+09   Median : 3.812
##                               Mean   :1990   Mean   :1.878e+11   Mean   : 3.684
##                               3rd Qu.:2006   3rd Qu.:5.450e+10   3rd Qu.: 6.298
##                               Max.   :2021   Max.   :2.332e+13   Max.   :149.973
##                               NA's    :5     NA's    :2448       NA's    :2937
##      GDP_pc          GDP_pc_ppp      inflation      natl_income_pc
##  Min.   : 12.79   Min.   : 284.2   Min.   :-17.640   Min.   :-422.9
##  1st Qu.: 550.85  1st Qu.: 2853.8  1st Qu.: 2.091   1st Qu.: 614.5
##  Median : 1973.61 Median : 8120.0  Median : 4.733   Median : 1924.8
##  Mean   : 8669.86 Mean   :15425.5  Mean   : 23.761  Mean   : 6544.5
##  3rd Qu.: 7961.48 3rd Qu.: 20853.3 3rd Qu.: 10.079  3rd Qu.: 6562.3
##  Max.   :234315.46 Max.   :163219.5  Max.   :23773.132 Max.   :155555.5
##  NA's    :2448     NA's    :6699     NA's    :4244     NA's    :5438
##      cpi             food        homicides      electricity
##  Min.   : 0.00   Min.   : 3.08   Min.   : 0.000   Min.   : 0.534
##  1st Qu.: 16.57  1st Qu.: 46.32  1st Qu.: 1.307   1st Qu.: 67.291
##  Median : 61.70  Median : 76.97  Median : 3.175   Median : 99.155
##  Mean   : 76.39  Mean   : 77.41  Mean   : 8.344   Mean   : 80.185
##  3rd Qu.: 100.00 3rd Qu.: 98.61  3rd Qu.: 9.544   3rd Qu.:100.000
##  Max.   :22570.71 Max.   :849.85  Max.   :141.723  Max.   :100.000
##  NA's    :4109    NA's    :2151    NA's    :8967    NA's    :7088
##      co2_emissions    education      mig_stock
##  Min.   : 0.000   Min.   : 0.000   Min.   : 121
##  1st Qu.: 0.561   1st Qu.: 8.000   1st Qu.: 25794
##  Median : 2.309   Median : 9.000   Median : 120776
##  Mean   : 4.295   Mean   : 9.434   Mean   : 729010
##  3rd Qu.: 6.233   3rd Qu.:11.000   3rd Qu.: 504726
##  Max.   :47.651   Max.   :17.000   Max.   :46627102
##  NA's    :6974    NA's    :8349    NA's    :10341

```

## 4.11 Correlation pairs

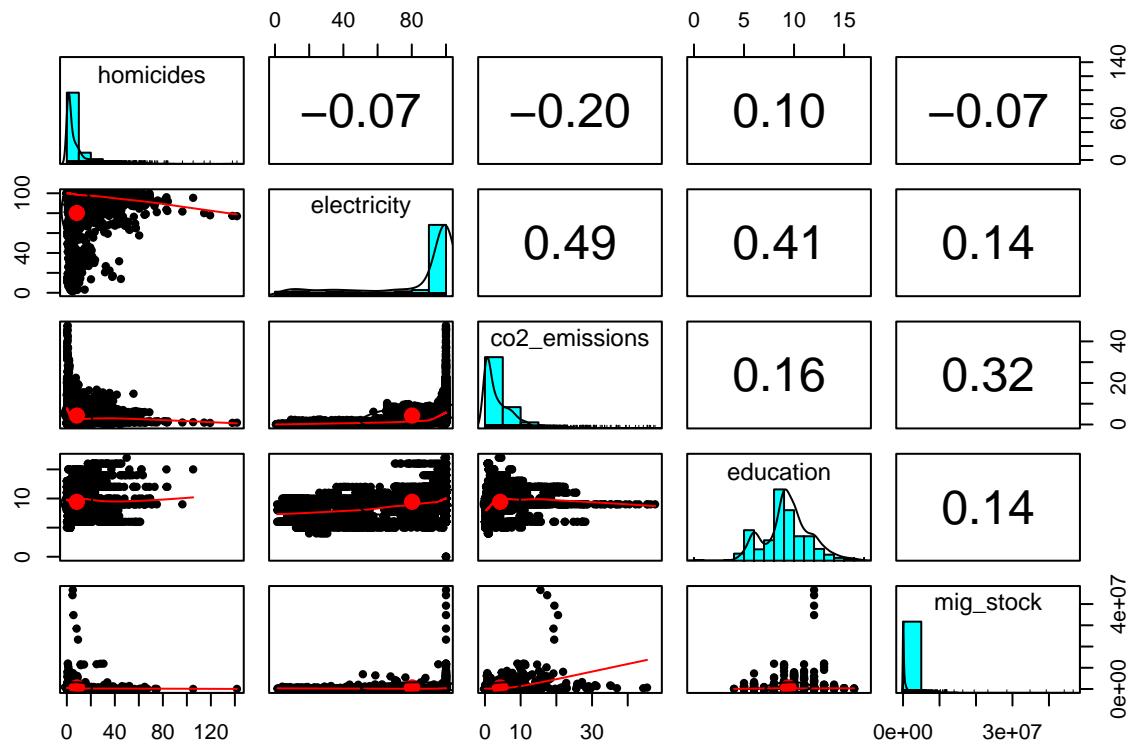
### 4.11.1 Economics indicators

```
wb[,3:9] %>% pairs.panels()
```



#### 4.11.2 Development indicators

```
wb[,11:15] %>% pairs.panels()
```



## 4.12 Transforms

Candidates for `log()` transformation are all of the economic variables except perhaps for `GDP_growth`:

- GDP
- GDP\_pc
- GDP\_pc\_ppp
- inflation
- natl\_income\_pc
- cpi
- mig\_stock

```
# Instead of replacing, add new log variables using dplyr mutate()
wb <- wb %>% mutate(log_GDP = log(GDP),
                      log_GDP_pc = log(GDP_pc),
                      log_GDP_pc_ppp = log(GDP_pc_ppp),
                      log_inflation = log(inflation + 20),
                      log_natl_income_pc = log(natl_income_pc + 500),
                      log_cpi = log(cpi),
                      log_mig_stock = log(mig_stock))
head(wb)
```

```
##   ISO3 year      GDP GDP_growth    GDP_pc GDP_pc_ppp inflation natl_income_pc
## 1 AFG 1960 537777811       NA  62.36937       NA        NA        NA
```

```

## 2 AFG 1961 548888896      NA 62.44370      NA      NA      NA
## 3 AFG 1962 546666678      NA 60.95036      NA      NA      NA
## 4 AFG 1963 751111191      NA 82.02174      NA      NA      NA
## 5 AFG 1964 800000044      NA 85.51107      NA      NA      NA
## 6 AFG 1965 1006666638     NA 105.24320     NA      NA      NA
##   cpi food homicides electricity co2_emissions education mig_stock log_GDP
## 1  NA    NA        NA        NA        NA      NA 46468 20.10296
## 2  NA 41.48       NA        NA        NA      NA 20.12341
## 3  NA 41.81       NA        NA        NA      NA 20.11935
## 4  NA 41.62       NA        NA        NA      NA 20.43706
## 5  NA 45.13       NA        NA        NA      NA 20.50012
## 6  NA 47.24       NA        NA        NA      NA 49535 20.72991
##   log_GDP_pc log_GDP_pc_ppp log_inflation log_natl_income_pc log_cpi
## 1  4.133074          NA        NA        NA      NA
## 2  4.134265          NA        NA        NA      NA
## 3  4.110060          NA        NA        NA      NA
## 4  4.406984          NA        NA        NA      NA
## 5  4.448646          NA        NA        NA      NA
## 6  4.656274          NA        NA        NA      NA
##   log_mig_stock
## 1      10.74652
## 2        NA
## 3        NA
## 4        NA
## 5        NA
## 6      10.81043

```

## 4.13 Summary and correlation pairs of log transformed variables

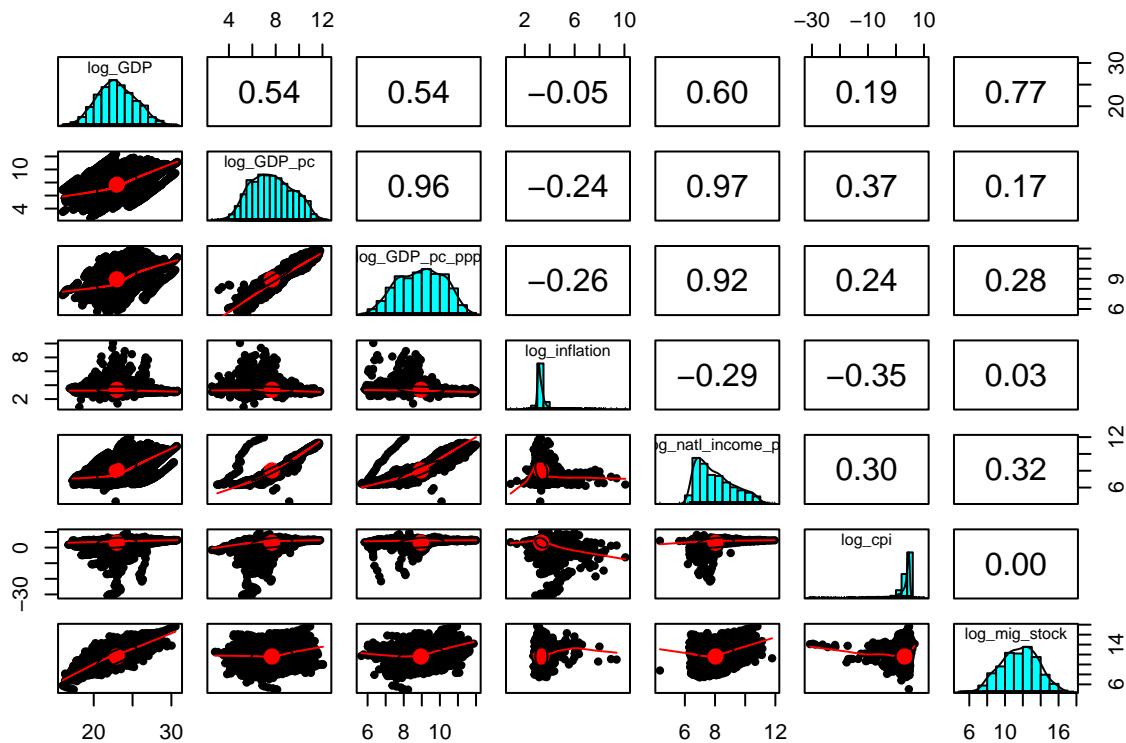
```
summary(wb[16:22])
```

```

##   log_GDP      log_GDP_pc      log_GDP_pc_ppp      log_inflation
## Min.   :15.99   Min.   : 2.548   Min.   : 5.650   Min.   : 0.858
## 1st Qu.:21.18   1st Qu.: 6.311   1st Qu.: 7.956   1st Qu.: 3.095
## Median :22.85   Median : 7.588   Median : 9.002   Median : 3.208
## Mean   :22.97   Mean   : 7.672   Mean   : 8.949   Mean   : 3.330
## 3rd Qu.:24.72   3rd Qu.: 8.982   3rd Qu.: 9.945   3rd Qu.: 3.404
## Max.   :30.78   Max.   :12.364   Max.   :12.003   Max.   :10.077
## NA's   :2448    NA's   :2448    NA's   :6699    NA's   :4244
##   log_natl_income_pc      log_cpi      log_mig_stock
## Min.   : 4.345   Min.   :-30.970   Min.   : 4.796
## 1st Qu.: 7.016   1st Qu.: 2.808   1st Qu.:10.158
## Median : 7.794   Median : 4.122   Median :11.702
## Mean   : 8.035   Mean   : 3.080   Mean   :11.603
## 3rd Qu.: 8.863   3rd Qu.: 4.605   3rd Qu.:13.132
## Max.   :11.958   Max.   :10.024   Max.   :17.658
## NA's   :5438    NA's   :4109    NA's   :10341

```

```
wb[16:22] %>% pairs.panels()
```



Do  $\log()$  transformation also for:

- food
- homicides
- electricity
- co2\_emissions
- education

For simplicity,  $\log$  transform all the numeric variables.

```
# Instead of replacing, add new log variables using dplyr mutate()

wb <- wb %>% mutate(log_food = log(food),
                      log_homicides = log(homicides + 0.01),
                      log_electricity = log(electricity),
                      log_co2_emissions = log(co2_emissions),
                      log_education = log(education + 0.01))

head(wb)
```

	IS03	year	GDP	GDP_growth	GDP_pc	GDP_pc_ppp	inflation	natl_income_pc
## 1	AFG	1960	537777811	NA	62.36937	NA	NA	NA
## 2	AFG	1961	548888896	NA	62.44370	NA	NA	NA
## 3	AFG	1962	546666678	NA	60.95036	NA	NA	NA
## 4	AFG	1963	751111191	NA	82.02174	NA	NA	NA
## 5	AFG	1964	800000044	NA	85.51107	NA	NA	NA

```

## 6 AFG 1965 1006666638 NA 105.24320 NA NA NA
## cpi food homicides electricity co2_emissions education mig_stock log_GDP
## 1 NA NA NA NA NA NA 46468 20.10296
## 2 NA 41.48 NA NA NA NA NA 20.12341
## 3 NA 41.81 NA NA NA NA NA 20.11935
## 4 NA 41.62 NA NA NA NA NA 20.43706
## 5 NA 45.13 NA NA NA NA NA 20.50012
## 6 NA 47.24 NA NA NA NA 49535 20.72991
## log_GDP_pc log_GDP_pc_ppp log_inflation log_natl_income_pc log_cpi
## 1 4.133074 NA NA NA NA
## 2 4.134265 NA NA NA NA
## 3 4.110060 NA NA NA NA
## 4 4.406984 NA NA NA NA
## 5 4.448646 NA NA NA NA
## 6 4.656274 NA NA NA NA
## log_mig_stock log_food log_homicides log_electricity log_co2_emissions
## 1 10.74652 NA NA NA NA
## 2 NA 3.725211 NA NA NA
## 3 NA 3.733136 NA NA NA
## 4 NA 3.728581 NA NA NA
## 5 NA 3.809547 NA NA NA
## 6 10.81043 3.855241 NA NA NA
## log_education
## 1 NA
## 2 NA
## 3 NA
## 4 NA
## 5 NA
## 6 NA

```

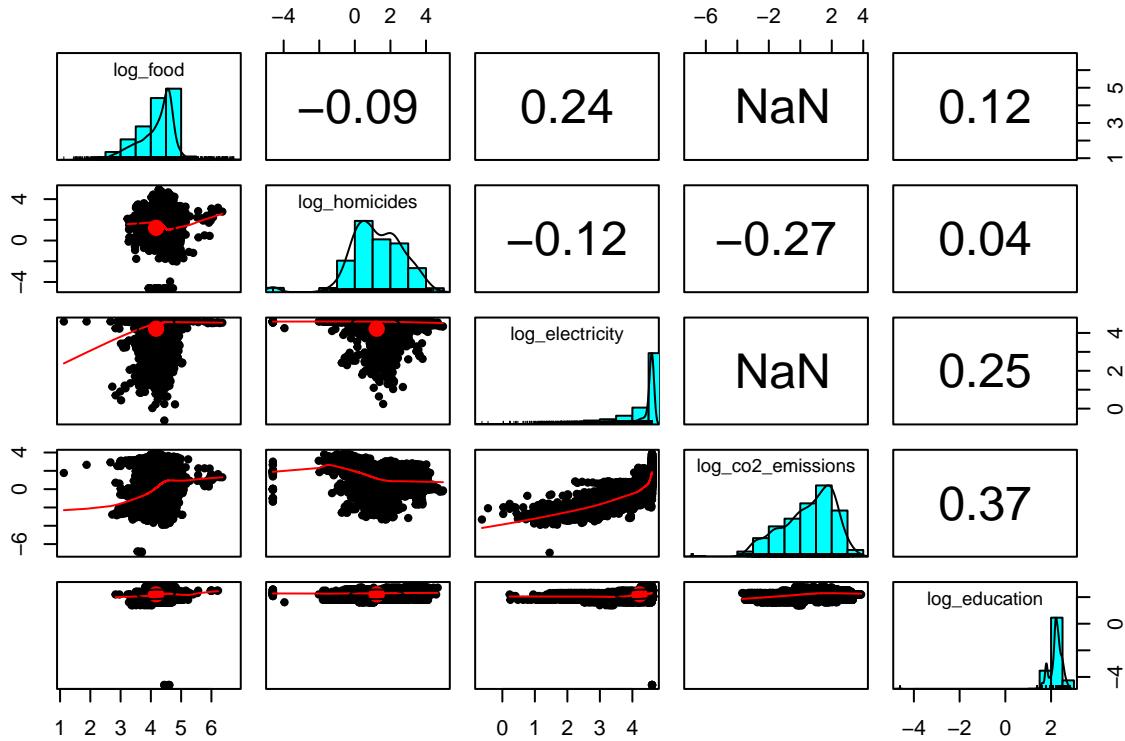
```
summary(wb[,23:27])
```

```

##      log_food      log_homicides      log_electricity      log_co2_emissions
## Min.   :1.125   Min.   :-4.605   Min.   :-0.628   Min.   : -Inf
## 1st Qu.:3.836   1st Qu.: 0.275   1st Qu.: 4.209   1st Qu.:-0.579
## Median :4.343   Median : 1.158   Median : 4.597   Median : 0.837
## Mean   :4.174   Mean   : 1.230   Mean   : 4.222   Mean   : -Inf
## 3rd Qu.:4.591   3rd Qu.: 2.257   3rd Qu.: 4.605   3rd Qu.: 1.830
## Max.   :6.745   Max.   : 4.954   Max.   : 4.605   Max.   : 3.864
## NA's   :2151    NA's   :8967    NA's   :7088    NA's   :6974
## log_education
## Min.   :-4.605
## 1st Qu.: 2.081
## Median : 2.198
## Mean   : 2.207
## 3rd Qu.: 2.399
## Max.   : 2.834
## NA's   :8349

```

```
wb[23:27] %>% pairs.panels()
```



## 5 Build the dataframe

### 5.1 Join WPP with WB by ISO3 and Year

We will use `dplyr` to perform the join, a.k.a. `merge` of two data sets.

We can either do a `left`, `inner`, or a `right` join. The order depends on which data set we pass first as an argument.

On a `left` join, the data set passed first (left argument) serves as the main data set. Matching records are added as new columns from the second data set. As a result, the number of rows will be determined by the `left`.

On an `inner` join, the two data sets are matched. The result will consist only of those observations/rows that are found in both data sets. Therefore, the number of rows will be less than or equal to that of the smaller data set.

And on a `right` join, the second data set takes precedence.

Here we will use the UN WPP data set as the main data set. We will apply a `left` join.

```
wpp_wb <- wpp %>% left_join(wb)
```

Notice the resulting data set `wpp_wb` has the same number of observations as `wpp`.

Now we have a data set with demographics and with economics data.

## 5.2 Reorder the data set columns

- Place non-numeric variables first
- Then outcome variables (migration related)
- Then the rest of the numeric variables.

## 5.3 Column names wpp\_wb

```
colnames(wpp_wb)
```

```
## [1] "index"                  "country"                 "subregion"
## [4] "region"                 "ISO3"                   "ISO2"
## [7] "year"                   "pop"                    "pop_m"
## [10] "pop_f"                  "pop_density"             "pop_sex_ratio"
## [13] "med_age"                "natural_change"          "natural_change_rate"
## [16] "pop_change"              "pop_growth_rate"         "births"
## [19] "births_w15to19"          "birth_rate"               "fertility_rate"
## [22] "net_reproduction_rate"   "mean_age_childbearing"  "sex_ratio_birth"
## [25] "tot_deaths"              "male_deaths"              "female_deaths"
## [28] "death_rate"              "life_exp"                "life_exp_m"
## [31] "life_exp_f"              "life_exp_15"              "life_exp_15_m"
## [34] "life_exp_15_f"           "life_exp_65"              "life_exp_65_m"
## [37] "life_exp_65_f"           "life_exp_80"              "life_exp_80_m"
## [40] "life_exp_80_f"           "infant_deaths"           "under_five_mortality"
## [43] "deaths_under_5"           "mortality_rate_under_5"  "mortality_40"
## [46] "mortality_40_m"           "mortality_40_f"           "mortality_60"
## [49] "mortality_60_m"           "mortality_60_f"           "mortality_15_50"
## [52] "mortality_15_50_m"        "mortality_15_50_f"        "mortality_15_60"
## [55] "mortality_15_60_m"        "mortality_15_60_f"        "net_migrants"
## [58] "net_mig_rate"              "net_mig_rate_mean"        "net_mig_rate_sd"
## [61] "net_mig_rate_med"          "net_mig_rate_25qtl"       "net_mig_rate_75qtl"
## [64] "emigrates"                "mig_pattern"              "migration_swings"
## [67] "GDP"                      "GDP_growth"               "GDP_pc"
## [70] "GDP_pc_ppp"              "inflation"                "natl_income_pc"
## [73] "cpi"                      "food"                     "homicides"
## [76] "electricity"              "co2_emissions"            "education"
## [79] "mig_stock"                "log_GDP"                  "log_GDP_pc"
## [82] "log_GDP_pc_ppp"           "log_inflation"             "log_natl_income_pc"
## [85] "log_cpi"                  "log_mig_stock"             "log_food"
## [88] "log_homicides"             "log_electricity"           "log_co2_emissions"
## [91] "log_education"
```

## 5.4 Separate non-numeric from outcome and predictor variables

```
# First group
# These describe/identify the observations, e.g. country/region name, ISO, year
non_num_cnames <- colnames(wpp_wb[, 1:7])

# Second group, outcomes and related migration vars
# This step will remove some columns as well
```

```

outcomes <- c('net_mig_rate',
             'net_migrants',
             'mig_stock',
             'log_mig_stock',
             'emigrates',
             'mig_pattern',
             'migration_swings',
             'net_mig_rate_mean',
             'net_mig_rate_med')

# Third group - Predictors
num_cnames <- colnames(wpp_wb[, 8:91])

predictors <- num_cnames[! num_cnames %in% c('net_mig_rate',
                                              'net_migrants',
                                              'migration_stock',
                                              'log_mig_stock',
                                              'emigrates',
                                              'mig_pattern',
                                              'migration_swings',
                                              'net_mig_rate_mean',
                                              'net_mig_rate_sd',
                                              'net_mig_rate_med',
                                              'net_mig_rate_25qtl',
                                              'net_mig_rate_75qtl'
                                         )]

```

## 5.5 Rearrange migration variables to the left of the numeric dataframe

```

wpp_wb <- wpp_wb %>% dplyr::select(non_num_cnames, outcomes, predictors)

# make categorical variables as factors
wpp_wb$mig_pattern <- as.factor(wpp_wb$mig_pattern)
wpp_wb$emigrates <- as.factor(wpp_wb$emigrates)
wpp_wb$migration_swings <- as.factor(wpp_wb$migration_swings)

colnames(wpp_wb)

```

## [1] "index"	"country"	"subregion"
## [4] "region"	"ISO3"	"ISO2"
## [7] "year"	"net_mig_rate"	"net_migrants"
## [10] "mig_stock"	"log_mig_stock"	"emigrates"
## [13] "mig_pattern"	"migration_swings"	"net_mig_rate_mean"
## [16] "net_mig_rate_med"	"pop"	"pop_m"
## [19] "pop_f"	"pop_density"	"pop_sex_ratio"
## [22] "med_age"	"natural_change"	"natural_change_rate"
## [25] "pop_change"	"pop_growth_rate"	"births"
## [28] "births_w15to19"	"birth_rate"	"fertility_rate"
## [31] "net_reproduction_rate"	"mean_age_childbearing"	"sex_ratio_birth"
## [34] "tot_deaths"	"male_deaths"	"female_deaths"
## [37] "death_rate"	"life_exp"	"life_exp_m"

```

## [40] "life_exp_f"           "life_exp_15"          "life_exp_15_m"
## [43] "life_exp_15_f"         "life_exp_65"          "life_exp_65_m"
## [46] "life_exp_65_f"         "life_exp_80"          "life_exp_80_m"
## [49] "life_exp_80_f"         "infant_deaths"       "under_five_mortality"
## [52] "deaths_under_5"        "mortality_rate_under_5" "mortality_40"
## [55] "mortality_40_m"        "mortality_40_f"       "mortality_60"
## [58] "mortality_60_m"        "mortality_60_f"       "mortality_15_50"
## [61] "mortality_15_50_m"      "mortality_15_50_f"     "mortality_15_60"
## [64] "mortality_15_60_m"      "mortality_15_60_f"     "GDP"
## [67] "GDP_growth"            "GDP_pc"              "GDP_pc_ppp"
## [70] "inflation"             "natl_income_pc"       "cpi"
## [73] "food"                  "homicides"            "electricity"
## [76] "co2_emissions"          "education"            "log_GDP"
## [79] "log_GDP_pc"             "log_GDP_pc_ppp"       "log_inflation"
## [82] "log_natl_income_pc"     "log_cpi"              "log_food"
## [85] "log_homicides"          "log_electricity"       "log_co2_emissions"
## [88] "log_education"

```

## 6 Train test split

Build a train test split up-front to be used consistently throughout this analysis.

```

# We have 236 countries.
countries <- unique(wpp_wb$country)

# Now get a sample of say 70% of that list
set.seed(12321)
countries_sample <- sample(countries, length(countries)*0.7)

# Now we will want train to contain those countries
# And test not to contain those countries.
train <- wpp_wb %>% filter(country %in% countries_sample)
test <- wpp_wb %>% filter(!country %in% countries_sample)

# Traditionally we would split the df up and down as follows
# set.seed(12321)
# ind <- sample(2, nrow(wpp_wb), replace = T, prob = c(0.7, 0.3))
# train <- wpp_wb[ind == 1,]
# test <- wpp_wb[ind == 2,]

# Another option data scientists use when splitting data that originates
# from a time series is by training from year 1 to year x
# and testing from years x+1 to last year.

```

### 6.1 Explore train and test sets

This shows the count of observations/rows:

### 6.1.1 By region

```
train %>%
  group_by(region) %>%
  summarize(count = n())

## # A tibble: 6 x 2
##   region           count
##   <chr>          <int>
## 1 AFRICA         2880
## 2 ASIA           2880
## 3 EUROPE         2016
## 4 LATIN AMERICA AND THE CARIBBEAN 2736
## 5 NORTHERN AMERICA      288
## 6 OCEANIA        1080

test %>%
  group_by(region) %>%
  summarize(count = n())

## # A tibble: 6 x 2
##   region           count
##   <chr>          <int>
## 1 AFRICA         1296
## 2 ASIA           792
## 3 EUROPE         1512
## 4 LATIN AMERICA AND THE CARIBBEAN 864
## 5 NORTHERN AMERICA      72
## 6 OCEANIA        576
```

### 6.1.2 By subregion

```
train %>%
  group_by(subregion) %>%
  summarize(count = n())

## # A tibble: 22 x 2
##   subregion       count
##   <chr>          <int>
## 1 Australia/New Zealand 144
## 2 Caribbean      1584
## 3 Central America 432
## 4 Central Asia    288
## 5 Eastern Africa 1008
## 6 Eastern Asia    504
## 7 Eastern Europe  576
## 8 Melanesia      288
## 9 Micronesia     216
## 10 Middle Africa 432
## # ... with 12 more rows
```

```

test %>%
  group_by(subregion) %>%
  summarize(count = n())

## # A tibble: 21 x 2
##   subregion      count
##   <chr>        <int>
## 1 Caribbean     432
## 2 Central America    144
## 3 Central Asia      72
## 4 Eastern Africa    432
## 5 Eastern Asia      72
## 6 Eastern Europe    144
## 7 Melanesia       72
## 8 Micronesia      288
## 9 Middle Africa    216
## 10 NORTHERN AMERICA    72
## # ... with 11 more rows

```

### 6.1.3 By country

```

train %>%
  group_by(country) %>%
  summarize(count = n())

## # A tibble: 165 x 2
##   country      count
##   <chr>        <int>
## 1 Afghanistan     72
## 2 Algeria         72
## 3 Andorra         72
## 4 Anguilla         72
## 5 Antigua and Barbuda    72
## 6 Argentina        72
## 7 Armenia          72
## 8 Australia         72
## 9 Austria          72
## 10 Azerbaijan       72
## # ... with 155 more rows

test %>%
  group_by(country) %>%
  summarize(count = n())

## # A tibble: 71 x 2
##   country      count
##   <chr>        <int>
## 1 Albania        72
## 2 American Samoa    72
## 3 Angola          72

```

```

## 4 Aruba 72
## 5 Belgium 72
## 6 Bonaire, Sint Eustatius and Saba 72
## 7 Bosnia and Herzegovina 72
## 8 Botswana 72
## 9 Brunei Darussalam 72
## 10 Central African Republic 72
## # ... with 61 more rows

```

#### 6.1.4 By year

```

train %>%
  group_by(year) %>%
  summarize(count = n())

```

```

## # A tibble: 72 x 2
##       year count
##   <dbl> <int>
## 1 1950    165
## 2 1951    165
## 3 1952    165
## 4 1953    165
## 5 1954    165
## 6 1955    165
## 7 1956    165
## 8 1957    165
## 9 1958    165
## 10 1959   165
## # ... with 62 more rows

```

```

test %>%
  group_by(year) %>%
  summarize(count = n())

```

```

## # A tibble: 72 x 2
##       year count
##   <dbl> <int>
## 1 1950    71
## 2 1951    71
## 3 1952    71
## 4 1953    71
## 5 1954    71
## 6 1955    71
## 7 1956    71
## 8 1957    71
## 9 1958    71
## 10 1959   71
## # ... with 62 more rows

```

The count of countries can be taken by looking at one single year (e.g. 2019)

### 6.1.5 Countries by region

```
train %>% filter(year == 2019) %>%
  group_by(region) %>%
  summarize(count = n())

## # A tibble: 6 x 2
##   region           count
##   <chr>          <int>
## 1 AFRICA            40
## 2 ASIA              40
## 3 EUROPE             28
## 4 LATIN AMERICA AND THE CARIBBEAN    38
## 5 NORTHERN AMERICA            4
## 6 OCEANIA            15

test %>% filter(year == 2019) %>%
  group_by(region) %>%
  summarize(count = n())

## # A tibble: 6 x 2
##   region           count
##   <chr>          <int>
## 1 AFRICA            18
## 2 ASIA              11
## 3 EUROPE             21
## 4 LATIN AMERICA AND THE CARIBBEAN    12
## 5 NORTHERN AMERICA            1
## 6 OCEANIA             8
```

## 7 Write to CSV to be used downstream

```
write.csv(wpp_wb, '../data/wpp_wb_2023.Q1.csv', row.names = FALSE)
write.csv(train, '../data/wpp_wb_train_2023.Q1.csv', row.names = FALSE)
write.csv(test, '../data/wpp_wb_test_2023.Q1.csv', row.names = FALSE)
```

## 8 References

1. United Nations Datamart - World Population Prospects (accessed Mar. 15, 2023) <https://population.un.org/wpp/Download/Standard/MostUsed/>
2. World Bank World Development Indicators (accessed Mar. 16, 2022) <https://databank.worldbank.org/source/world-development-indicators>
3. World Bank World Development Indicators. Data\_Extract (accessed Mar. 18, 2023) <https://databank.worldbank.org/Countries-GDP-and-Inflation/id/4f7a6fed>
4. Migration Policy Institute. “Immigration Has Been a Defining, Often Contentious, Element Throughout U.S. History.” Jan. 6, 2022 (accessed Mar 30, 2023) <https://www.migrationpolicy.org/article/immigration-shaped-united-states-history>

5. International Organization for Migration (IOM). "World Migration Report 2022." ISBN 978-92-9268-078-7. (accessed Apr. 24, 2023) <https://publications.iom.int/books/world-migration-report-2022>
6. International Organization for Migration (IOM) Global Migration Analysis Centre. Migration Data Portal (accessed Apr. 14, 2023) <https://www.migrationdataportal.org/>
7. IOM Migration Research Series. "Gallup World Poll: The Many Faces of Global Migration." <https://news.gallup.com/poll/152660/Faces-Global-Migration.aspx>
8. World Migration Report 2022. (accessed Apr. 10m 2023) <https://migrationnetwork.un.org/resources/world-migration-report-2022>

## Useful links

- United Nations Datamart: <http://data.un.org/>
- United Nations Datamart - World Population Prospects (WPP): <https://population.un.org/wpp/Download/Standard/MostUsed/>
- United Nations Datamart - World Population Prospects Excel file: [https://population.un.org/wpp/Download/Files/1\\_Indicators%20\(Standard\)/EXCEL\\_FILES/1\\_General/WPP2022\\_GEN\\_F01\\_DEMOGRAPHIC\\_INDICATORS\\_REV1.xlsx](https://population.un.org/wpp/Download/Files/1_Indicators%20(Standard)/EXCEL_FILES/1_General/WPP2022_GEN_F01_DEMOGRAPHIC_INDICATORS_REV1.xlsx)
- United Nations Datamart - Economic Trading: <https://population.un.org/wpp/Download/SpecialAggregates/EconomicTrading/>
- United Nations GDP: [http://data.un.org/\\_Docs/SYB/CSV/SYB65\\_230\\_202209\\_GDP%20and%20GDP%20Per%20Capita.csv](http://data.un.org/_Docs/SYB/CSV/SYB65_230_202209_GDP%20and%20GDP%20Per%20Capita.csv)
- World Bank DataBank. Global Bilateral Migration: <https://databank.worldbank.org/source/global-bilateral-migration/Type/TABLE/preview/on#>
- World Bank Inflation: <https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?view=chart>
- World Bank World Development Indicators P\_Data\_Extract\_From\_World\_Development\_Indicators <https://databank.worldbank.org/source/world-development-indicators>
- World Bank World GDP: <https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG> file API\_NY.GDP.MKTP.KD.ZG\_DS2\_en\_excel\_v2\_4701280.xls
- US DHS Statistics: <https://www.dhs.gov/immigration-statistics/naturalizations>
- U.S. Naturalizations 2021 Data Tables: [https://www.dhs.gov/sites/default/files/2022-09/2022\\_0624\\_plcy\\_naturalizations\\_fy2021\\_tables.zip](https://www.dhs.gov/sites/default/files/2022-09/2022_0624_plcy_naturalizations_fy2021_tables.zip)
- US Naturalizations: [https://www.dhs.gov/sites/default/files/2022-07/2022\\_0624\\_plcy\\_naturalizations\\_fy2021.pdf](https://www.dhs.gov/sites/default/files/2022-07/2022_0624_plcy_naturalizations_fy2021.pdf)