Project2

Ted Kim & Seung Min Song

2022-10-04

1. Joyce Aldrich's Real GDP by County Comparing all industies GDP grow rate for each county

Read csv file into a data frame **real_dgp_by_county**. The first three rows are headers, therefore set the header option to *False*.

```
real_gdp_by_county <- read.csv('./gdp_by_county.csv', header = FALSE, sep = ',')
head(real_gdp_by_county)
```

```
##      V1          V2     V3       V4                                      V5
## 1  FIPS Countyname Postal LineCode                           IndustryName
## 2
## 3
## 4 01001    Autauga     AL        1                         All Industries
## 5 01001    Autauga     AL        2     Private goods-producing industries
## 6 01001    Autauga     AL        3   Private services-providing industries
##                                         V6      V7      V8      V9
## 1 Real Gross domestic product (GDP) by county
## 2         (thousands of chained 2012 dollars)
## 3                                       2012    2013    2014    2015
## 4                                    1383941 1322416 1312668 1412939
## 5                                     286396  299115  310672  325250
## 6                                     948490  880098  861153  946148
```

Reset the header in the data frame. Use first row value for column one trough five and use third row value for column six through nine.

```
header <- real_gdp_by_county[1, ] %>%
            select(c(1:5))
header <- unlist(c(header, real_gdp_by_county[3, ] %>%
                             select(c(6:9))))
colnames(real_gdp_by_county) = header
head(real_gdp_by_county)
```

```
##    FIPS Countyname Postal LineCode                             IndustryName
## 1  FIPS Countyname Postal LineCode                             IndustryName
## 2
## 3
## 4 01001    Autauga     AL        1                           All Industries
## 5 01001    Autauga     AL        2      Private goods-producing industries
## 6 01001    Autauga     AL        3   Private services-providing industries
##                                        2012    2013    2014    2015
## 1 Real Gross domestic product (GDP) by county
## 2         (thousands of chained 2012 dollars)
## 3                                      2012    2013    2014    2015
## 4                                   1383941 1322416 1312668 1412939
## 5                                    286396  299115  310672  325250
## 6                                    948490  880098  861153  946148
```

Use *slice( )* function to remove unnecessary rows from the data frame. Remove rows one to three which overlap the header and the last four rows which is not relevant to current data.

```
real_gdp_by_county <- real_gdp_by_county %>%
                        slice(4:(n() - 4))
head(real_gdp_by_county)
```

```
##    FIPS Countyname Postal LineCode                             IndustryName
## 1 01001    Autauga     AL        1                           All Industries
## 2 01001    Autauga     AL        2      Private goods-producing industries
## 3 01001    Autauga     AL        3   Private services-providing industries
## 4 01001    Autauga     AL        4   Government and government enterprises
## 5 01003    Baldwin     AL        1                           All Industries
## 6 01003    Baldwin     AL        2      Private goods-producing industries
##      2012    2013    2014    2015
```

```
## 1 1383941 1322416 1312668 1412939
## 2  286396  299115  310672  325250
## 3  948490  880098  861153  946148
## 4  149055  143062  140893  141294
## 5 5599194 6218819 6247887 5981958
## 6  681871  675300  667273  681451
```

```
tail(real_gdp_by_county)
```

```
##        FIPS Countyname Postal LineCode                             IndustryName
## 12447 56043   Washakie     WY        3   Private services-providing industries
## 12448 56043   Washakie     WY        4   Government and government enterprises
## 12449 56045     Weston     WY        1                          All Industries
## 12450 56045     Weston     WY        2     Private goods-producing industries
## 12451 56045     Weston     WY        3   Private services-providing industries
## 12452 56045     Weston     WY        4   Government and government enterprises
##         2012   2013   2014   2015
## 12447 167938 179501 192289 195478
## 12448  62263  62283  61337  59740
## 12449 332472 311082 317811 388824
## 12450 181482 158661 162602 239734
## 12451  96240  95353  99420 104625
## 12452  54750  56535  55338  53722
```

Normalize data frame by three data frame, *df_county*, *df_industry_name*, and *df_real_gdf_wider*. Remove duplicated row and use *unique( )* function to make it unique.

```
df_county <- unique(real_gdp_by_county %>%
                      select(c(1:3))) #FIPS, CountyName, Postal
head(df_county)
```

```
##     FIPS Countyname Postal
## 1  01001    Autauga     AL
## 5  01003    Baldwin     AL
## 9  01005    Barbour     AL
## 13 01007       Bibb     AL
## 17 01009     Blount     AL
## 21 01011    Bullock     AL
```

```
df_industry_name <- unique(real_gdp_by_county %>%
                      select(c(4:5))) #LineCode, IndustryName
head(df_industry_name)
```

```
##   LineCode                            IndustryName
## 1        1                           All Industries
## 2        2      Private goods-producing industries
## 3        3   Private services-providing industries
## 4        4   Government and government enterprises
```

```
df_real_gdf_wider <- real_gdp_by_county %>%
                        select(c(1, 4, 6:9)) #FIPS, LineCode, '2012', '2013', '2014', '2015'
head(df_real_gdf_wider)
```

```
##    FIPS LineCode    2012    2013    2014    2015
## 1 01001        1 1383941 1322416 1312668 1412939
## 2 01001        2  286396  299115  310672  325250
## 3 01001        3  948490  880098  861153  946148
## 4 01001        4  149055  143062  140893  141294
## 5 01003        1 5599194 6218819 6247887 5981958
## 6 01003        2  681871  675300  667273  681451
```

Transfer into a tidy data frame. After that, Use *pivot_longer( )* function to pivot from column *2012* to last column *2015*. Did not use *values_drop_na = TRUE* since there are no cells with NA value. Change all values with *D* to *0* after the pivot.

(D) Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals

```
df_real_gdf_longer <- df_real_gdf_wider %>%
                        pivot_longer(
                          cols = colnames(df_real_gdf_wider)[-c(1,2)],
                          names_to = 'Year',
                          values_to = 'RealGDP'
                        ) %>%
                        mutate(
                          RealGDP = ifelse(RealGDP == '(D)', 0, as.double(RealGDP))
                        )
```

```
## Warning in ifelse(RealGDP == "(D)", 0, as.double(RealGDP)): NAs introduced by
## coercion
```

```
head(df_real_gdf_longer)
```

```
## # A tibble: 6 x 4
##   FIPS  LineCode Year  RealGDP
##   <chr> <chr>    <chr>   <dbl>
## 1 01001 1        2012  1383941
## 2 01001 1        2013  1322416
## 3 01001 1        2014  1312668
## 4 01001 1        2015  1412939
## 5 01001 2        2012   286396
## 6 01001 2        2013   299115
```

```
tail(df_real_gdf_longer)
```

```
## # A tibble: 6 x 4
##   FIPS  LineCode Year  RealGDP
##   <chr> <chr>    <chr>   <dbl>
## 1 56045 3        2014    99420
## 2 56045 3        2015   104625
## 3 56045 4        2012    54750
## 4 56045 4        2013    56535
## 5 56045 4        2014    55338
## 6 56045 4        2015    53722
```

Convert *Year* and *RealGDP* data type; Character to double.

```
df_real_gdf_longer$Year = as.numeric(df_real_gdf_longer$Year)
df_real_gdf_longer$RealGDP = as.numeric(df_real_gdf_longer$RealGDP)
```

Use *merge( )* to match *FIPS* and *Countyname*. Calculate *LineCode 1* (all industries) growth rate for each county. Replace *NA* value with *0*.

```
df_real_gdf_longer <- merge(x = df_real_gdf_longer, y = df_county, by = 'FIPS')  %>%
  group_by(FIPS, LineCode) %>%
    mutate(
      Prev_GDP = ifelse(is.na(lag(RealGDP)), 0, lag(RealGDP)),
```

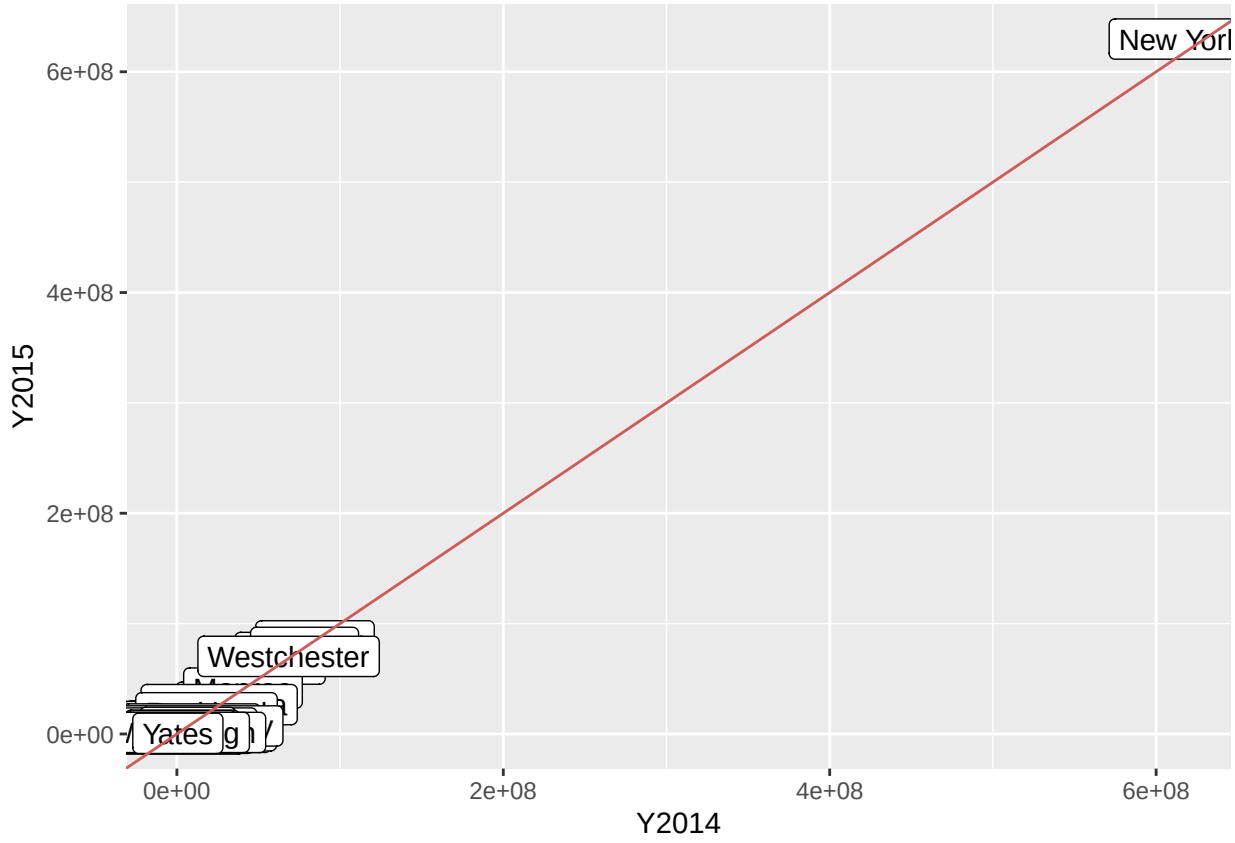
```
      Diff_growth = ifelse(is.na(lag(RealGDP)), 0, RealGDP - lag(RealGDP)),
      Rate_growth = ifelse(is.na(lag(RealGDP)), 0, round((RealGDP / lag(RealGDP) - 1) * 100, digits = 2)
      )
df_real_gdf_longer
```

```
## # A tibble: 49,808 x 9
## # Groups:   FIPS, LineCode [12,452]
##    FIPS  LineCode  Year RealGDP Countyname Postal Prev_GDP Diff_growth Rate_gr~1
##    <chr> <chr>    <dbl>   <dbl> <chr>      <chr>     <dbl>       <dbl>     <dbl>
##  1 01001 1         2012 1383941 Autauga    AL            0           0      0
##  2 01001 1         2013 1322416 Autauga    AL      1383941      -61525     -4.45
##  3 01001 1         2014 1312668 Autauga    AL      1322416       -9748     -0.74
##  4 01001 1         2015 1412939 Autauga    AL      1312668      100271      7.64
##  5 01001 2         2012  286396 Autauga    AL            0           0      0
##  6 01001 2         2013  299115 Autauga    AL       286396       12719      4.44
##  7 01001 2         2014  310672 Autauga    AL       299115       11557      3.86
##  8 01001 2         2015  325250 Autauga    AL       310672       14578      4.69
##  9 01001 3         2012  948490 Autauga    AL            0           0      0
## 10 01001 3         2013  880098 Autauga    AL       948490      -68392     -7.21
## # ... with 49,798 more rows, and abbreviated variable name 1: Rate_growth
```

Use *ggplot( ) + geom_point + geom_label* to compare 2014 and 2015's all industries' summarized GDP growth rate. *geom_abline* displays the red line in the graph and any blue dots above the red line indicate a positive growth rate and blue dots below the red line indicate a negative growth rate. Most of the county's GDP increased comared to 2014. Most of the county falls in between 0e+00 and 2e+08.

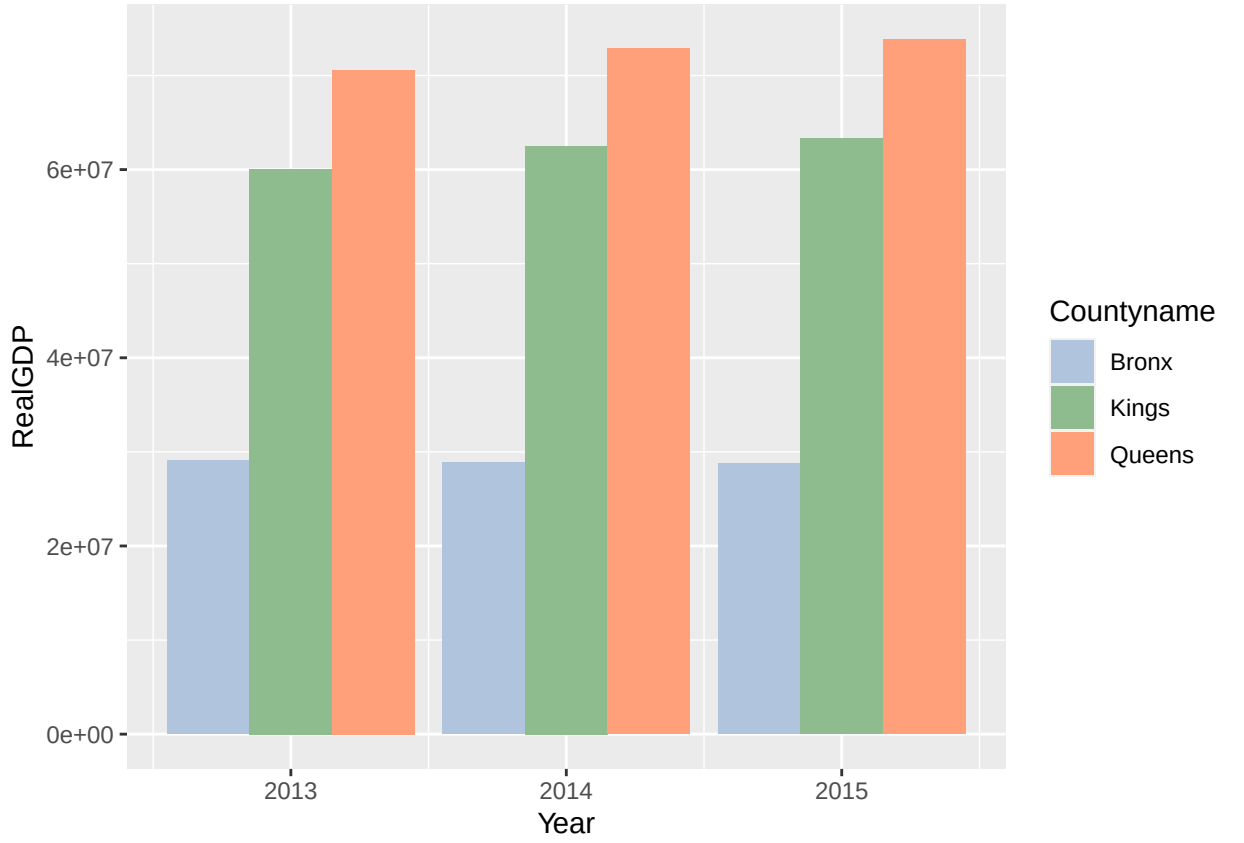
```
df_real_gdf_longer %>%
  filter(LineCode == '1', Postal == 'NY', Year == 2015) %>%
  ggplot(aes(x = Prev_GDP, y = RealGDP, label = Countyname), color = 'SteelBlue') +
  geom_point() +
  geom_label(
    nudge_x = 0.25, nudge_y = 0.25,
    check_overlap = T
  ) +
  geom_abline(intercept = 0, slope = 1, size = 0.5, color = 'IndianRed') +
  labs(
    x = 'Y2014',
```

```
    y = 'Y2015'
  )
```



Use 2013, 2014, and 2015 Queens, Brooklyn, and the Bronx's all industry's GDP growth rate and compare. Do not have to use 2012 because it has nothing to compare with.

```
counties <- c('Bronx', 'Queens', 'Kings')
df_real_gdf_longer %>%
  filter(LineCode == '1', Year != 2012, Postal == 'NY', Countyname %in% counties) %>%
  ggplot(aes(x = Year, y = RealGDP, fill = Countyname)) +
    geom_bar(stat = 'identity', position = 'dodge') +
    scale_color_manual(values = c('SteelBlue', 'OliveDrab', 'Coral')) +
    scale_fill_manual(values = c('LightSteelBlue', 'DarkSeaGreen', 'LightSalmon'))
```



2. Jawaid Hakim's Pharmaceutical Drug Spending by Countries An interesting analysis would be to plot the growth in spend by country over time, and comparison of growth in spend between countries.

Read csv file into a data frame **drug_spend_wider**. Only the first row is head, therefore set the header option to *True*.

```
drug_spend_wider <- read.csv('./drug_spending.csv', header = TRUE, sep = ',')
head(drug_spend_wider)
```

```
##   LOCATION TIME PC_HEALTHXP PC_GDP USD_CAP FLAG_CODES TOTAL_SPEND
## 1      AUS 1971      15.992  0.727  35.720                462.11
## 2      AUS 1972      15.091  0.686  36.056                475.11
## 3      AUS 1973      15.117  0.681  39.871                533.47
## 4      AUS 1974      14.771  0.755  47.559                652.65
## 5      AUS 1975      11.849  0.682  47.561                660.76
## 6      AUS 1976      10.920  0.630  46.908                658.26
```

Transfer into a tidy data frame. Remove column 6 named FLAG_CODES in *drug_spend_wider* data frame. Use *pivot_longer( )* function to pivot from column *PC_HEALTHXP* to last column *TOTAL SPEND*. Did not use *values_drop_na = TRUE* since there are no cells with NA value.

```
drug_spend_longer <- drug_spend_wider %>%
                         select(-c(6)) %>%
                         pivot_longer(
                           cols = colnames(drug_spend_wider)[-c(1,2, 6)],
                           names_to = 'Measure',
                           values_to = 'Value'
                         )
head(drug_spend_longer)
```

```
## # A tibble: 6 x 4
##   LOCATION  TIME Measure       Value
##   <chr>    <int> <chr>         <dbl>
## 1 AUS       1971 PC_HEALTHXP  16.0
## 2 AUS       1971 PC_GDP        0.727
## 3 AUS       1971 USD_CAP      35.7
## 4 AUS       1971 TOTAL_SPEND 462.
## 5 AUS       1972 PC_HEALTHXP  15.1
## 6 AUS       1972 PC_GDP        0.686
```

```
tail(drug_spend_longer)
```

```
## # A tibble: 6 x 4
##   LOCATION  TIME Measure       Value
##   <chr>    <int> <chr>         <dbl>
## 1 SVN       2011 USD_CAP      483.
## 2 SVN       2011 TOTAL_SPEND  991.
## 3 SVN       2012 PC_HEALTHXP   20.2
## 4 SVN       2012 PC_GDP         1.77
## 5 SVN       2012 USD_CAP      510.
## 6 SVN       2012 TOTAL_SPEND 1048.
```

Calculate the total spending rate for each country. Compare with data from 10 years ago.

```
drug_spend_longer <- drug_spend_longer %>%
  group_by(LOCATION) %>%
  filter(Measure =='TOTAL_SPEND')  %>%
    mutate(
      Prev_spend = ifelse(is.na(lag(Value, n = 10)), 0, lag(Value, n = 10)),
      Diff_spend = Value - lag(Value),
      Rate_percent = round((Value / lag(Value) - 1) * 100, digits = 2)
      )
drug_spend_longer
```

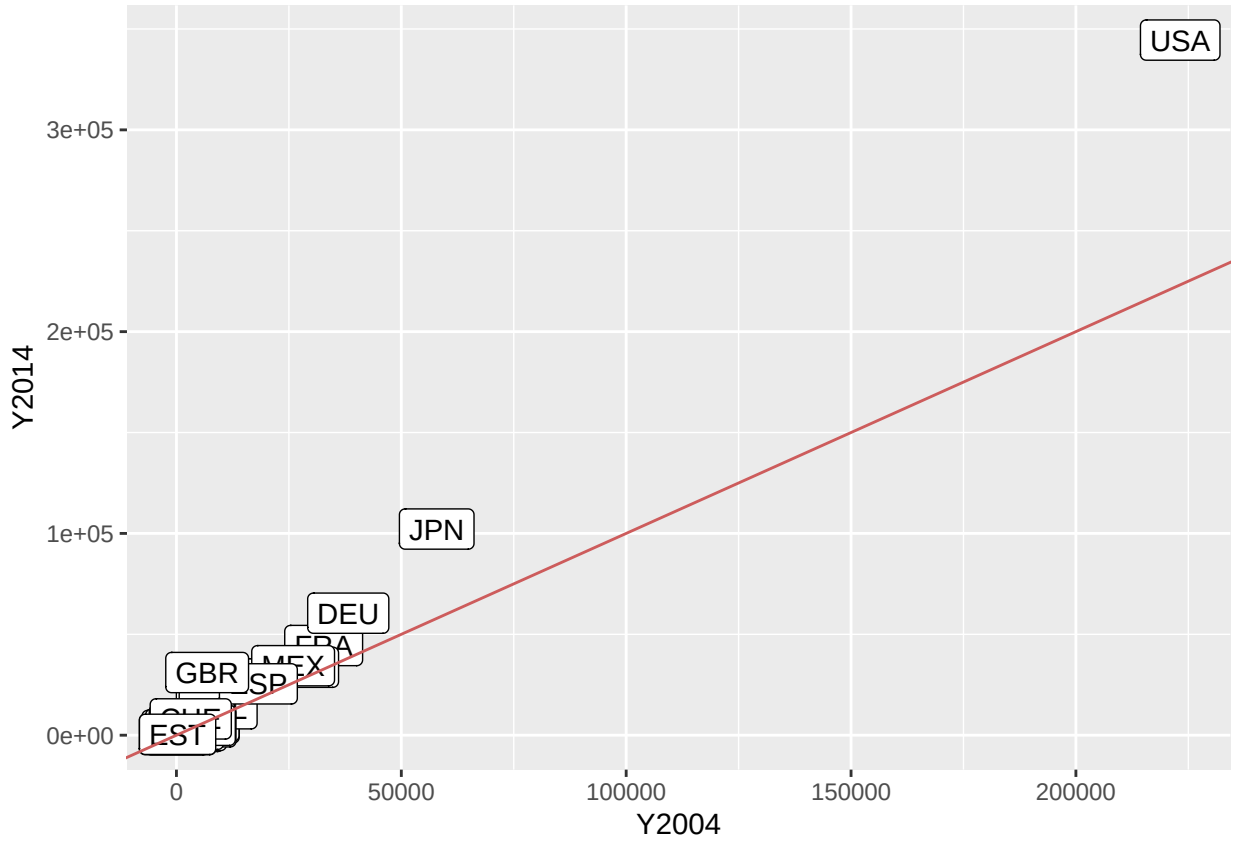
```
## # A tibble: 1,000 x 7
## # Groups:   LOCATION [32]
##    LOCATION  TIME Measure     Value Prev_spend Diff_spend Rate_percent
##    <chr>    <int> <chr>       <dbl>      <dbl>      <dbl>        <dbl>
##  1 AUS       1971 TOTAL_SPEND  462.          0      NA           NA
##  2 AUS       1972 TOTAL_SPEND  475.          0      13            2.81
##  3 AUS       1973 TOTAL_SPEND  533.          0      58.4         12.3
##  4 AUS       1974 TOTAL_SPEND  653.          0     119.          22.3
##  5 AUS       1975 TOTAL_SPEND  661.          0       8.11         1.24
##  6 AUS       1976 TOTAL_SPEND  658.          0      -2.5         -0.38
##  7 AUS       1977 TOTAL_SPEND  676.          0      18.0          2.73
##  8 AUS       1978 TOTAL_SPEND  729.          0      53.1          7.86
##  9 AUS       1979 TOTAL_SPEND  722.          0      -7.07        -0.97
## 10 AUS       1980 TOTAL_SPEND  837.          0     115.          15.9
## # ... with 990 more rows
```

Use *ggplot() + geom_point* to Compare 2004 and 2014. *geom_abline* displays the red line in the graph. Any blue dots above the red line indicate a positive spending rate and blue dots below the red line indicate a negative spending rate. Most of the nation spent more in 2014 compare to 2004.

```
drug_spend_longer %>%
  filter(TIME == 2014) %>%
  ggplot(aes(x = Prev_spend, y = Value, label = LOCATION), color = 'SteelBlue') +
  geom_point() +
  geom_label(
    nudge_x = 0.25, nudge_y = 0.25,
    check_overlap = T
```

```
  ) +
  geom_abline(intercept = 0, slope = 1, size = 0.5, color = 'IndianRed') +
  labs(
    x = 'Y2004',
    y = 'Y2014'
  )
```

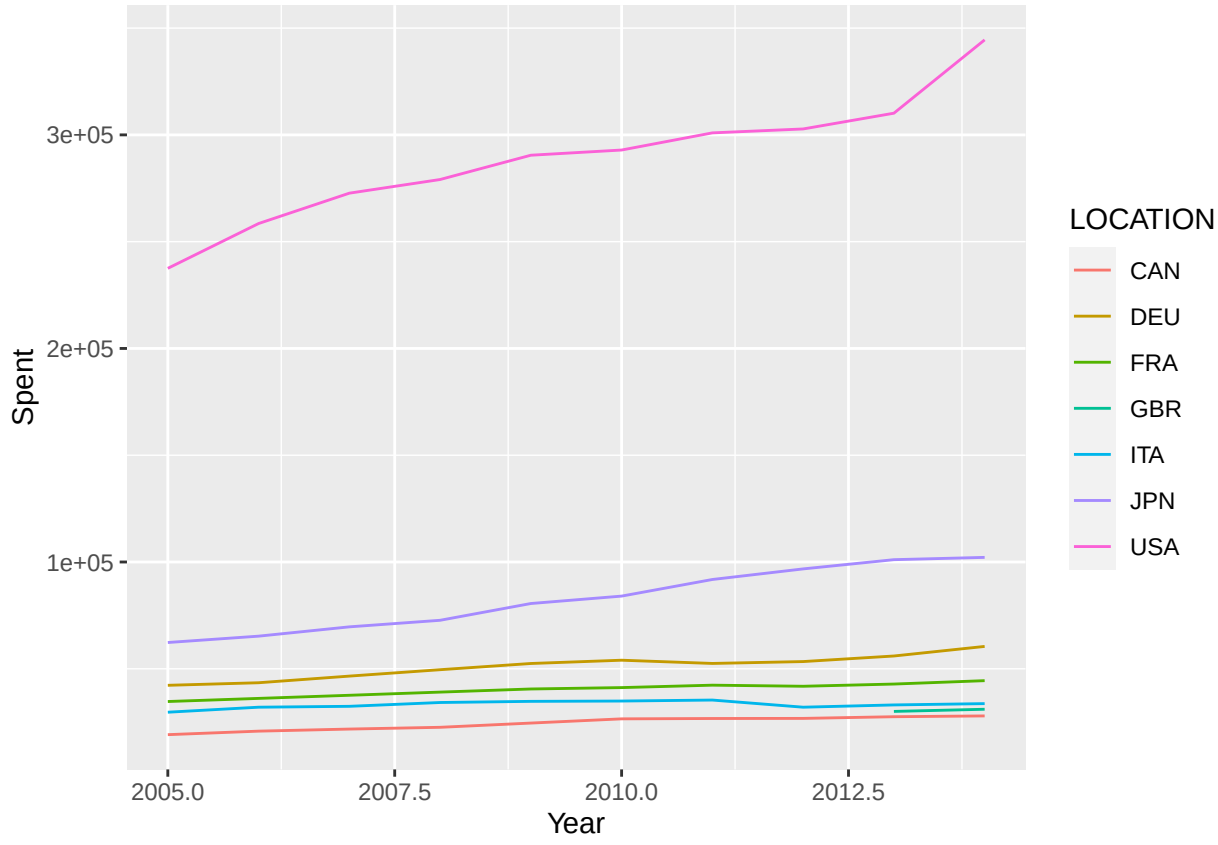
```
## Warning: Ignoring unknown parameters: check_overlap
```



Compare drug spending for G7 country in a 10-year cycle. Overall, drug spending in the US is significantly higher than other g7 countries, and drug spending in g7 countries has also steadily increased.

```
#DEU: Germany, GBR: the United Kingdom
G7 <- c('CAN', 'FRA', 'DEU', 'ITA', 'JPN', 'GBR', 'USA')
drug_spend_longer %>%
  filter(LOCATION %in% G7, TIME > 2004, TIME < 2015) %>%
  ggplot(aes(x = TIME, y = Value, color = LOCATION)) +
    geom_line() +
    labs(
```

```
    x = 'Year',
    y = 'Spent'
  )
```



3. Benjamin Inbar's Global GDP Dataset 1960-2021

One interesting analysis would be to get the % change year on year, per country, or per region.

Read csv file into a data frame **global_gdp**. Only the first row is head, therefore set the header option to *True*.

```
global_gdp <- read.csv('./global_gdp_1960_2021.csv', header = TRUE, sep = ',')
head(global_gdp)
```

```
##                   Country.Name Country.Code    Indicator.Name Indicator.Code
## 1                        Aruba          ABW GDP (current US$) NY.GDP.MKTP.CD
## 2 Africa Eastern and Southern          AFE GDP (current US$) NY.GDP.MKTP.CD
## 3                  Afghanistan          AFG GDP (current US$) NY.GDP.MKTP.CD
## 4  Africa Western and Central          AFW GDP (current US$) NY.GDP.MKTP.CD
```

```
## 5                    Angola          AGO GDP (current US$) NY.GDP.MKTP.CD
## 6                   Albania          ALB GDP (current US$) NY.GDP.MKTP.CD
##         X1960       X1961       X1962       X1963       X1964       X1965
## 1          NA          NA          NA          NA          NA          NA
## 2 21290586003 21808473825 23707015394 28210036878 26118787467 29682172751
## 3   537777811   548888896   546666678   751111191   800000044  1006666638
## 4 10404135069 11127894641 11943187848 12676330765 13838369295 14862225760
## 5          NA          NA          NA          NA          NA          NA
## 6          NA          NA          NA          NA          NA          NA
##         X1966       X1967       X1968       X1969       X1970       X1971
## 1          NA          NA          NA          NA          NA          NA
## 2 32239121547 33514552047 36521482937 41828336213 44862605393 49478916698
## 3  1399999967  1673333418  1373333367  1408888922  1748886596  1831108971
## 4 15832591204 14426038230 14880349280 16882092549 23504605476 20832817218
## 5          NA          NA          NA          NA          NA          NA
## 6          NA          NA          NA          NA          NA          NA
##         X1972       X1973       X1974       X1975       X1976        X1977
## 1          NA          NA          NA          NA          NA           NA
## 2 53514844534 69600788111 86057777551 91649152687 91124551926 103416000000
## 3  1595555476  1733333264  2155555498  2366666616  2555555567   2953333418
## 4 25264953766 31273819026 44214484997 51444731784 62129390375  65315008068
## 5          NA          NA          NA          NA          NA           NA
## 6          NA          NA          NA          NA          NA           NA
##          X1978       X1979        X1980        X1981        X1982        X1983
## 1           NA          NA           NA           NA           NA           NA
## 2 115345000000 1.34671e+11 170654000000 174387000000 167266000000 174918000000
## 3   3300000109 3.69794e+09   3641723322   3478787909           NA           NA
## 4  71199708192 8.86284e+10 112031000000 211003000000 187164000000 138115000000
## 5           NA          NA   5930503401   5550483036   5550483036   5784341596
## 6           NA          NA           NA           NA           NA           NA
##          X1984       X1985        X1986        X1987        X1988        X1989
## 1           NA          NA    405586592    487709497    596648045    695530726
## 2 160134000000 1.36297e+11 152518000000 186145000000 204140000000 217539000000
## 3           NA          NA           NA           NA           NA           NA
## 4 114263000000 1.16507e+11 107498000000 110322000000 108943000000 101769000000
## 5   6131475065 7.55356e+09   7072063346   8083872012   8769250550  10201099039
```

```
## 6   1857338012 1.89705e+09   2097326250   2080796250   2051236250   2253090000
##          X1990        X1991        X1992        X1993        X1994        X1995
## 1    764804469    872067039    958659218   1083240223   1245810056   1320670391
## 2 253224000000 273403000000 238255000000 236527000000 240120000000 269637000000
## 3           NA           NA           NA           NA           NA           NA
## 4 121802000000 117457000000 118282000000  98826369836  86281743753 108221000000
## 5  11228764963  10603784541   8307810974   5768720422   4438321017   5538749260
## 6   2028553750   1099559028    652174991   1185315468   1880951520   2392764853
##          X1996        X1997        X1998        X1999        X2000        X2001
## 1   1379888268   1531843575   1665363128   1722905028   1873184358   1896648045
## 2 268414000000 282185000000 265814000000 262172000000 283925000000 258819000000
## 3           NA           NA           NA           NA           NA           NA
## 4 125763000000 127064000000 130107000000 137521000000 140410000000 148013000000
## 5   7526446606   7648377413   6506229607   6152922943   9129594819   8936063723
## 6   3199641336   2258513974   2545964541   3212121651   3480355258   3922100794
##          X2002        X2003        X2004        X2005        X2006        X2007
## 1   1962011173   2044134078   2254748603   2359776536   2469832402   2677653631
## 2 264870000000 352659000000 438834000000 512211000000 575921000000 661179000000
## 3   4055179566   4515558808   5226778809   6209137625   6971285595   9747879532
## 4 176938000000 204645000000 254093000000 310558000000 393305000000 461791000000
## 5  15285594828  17812704825  23552047248  36970918699  52381006892  65266452081
## 6   4348068242   5611496257   7184685782   8052073539   8896072919  10677324144
##          X2008        X2009        X2010        X2011        X2012        X2013
## 1   2843016760   2553631285   2453631285   2637988827   2615083799   2727932961
## 2 708287000000 719217000000 860478000000 964418000000 973043000000 983937000000
## 3  10109305183  12416161049  15856678596  17805113119  19907317066  20146404996
## 4 566481000000 507044000000 591596000000 670983000000 727570000000 820793000000
## 5  88538610805  70307166934  81699556137 109437000000 124998000000 133402000000
## 6  12881353508  12044208086  11926922829  12890764531  12319830437  12776220507
##          X2014        X2015        X2016        X2017        X2018        X2019
## 1 2.791061e+09   2963128492   2983798883 3.092179e+09   3202234637   3310055866
## 2 1.003680e+12 924253000000 882355000000 1.020650e+12 991022000000 997534000000
## 3 2.049713e+10  19134211764  18116562465 1.875347e+10  18053228579  18799450743
## 4 8.649900e+11 760734000000 690546000000 6.837490e+11 741690000000 794543000000
## 5 1.372440e+11  87219290029  49840494026 6.897276e+10  77792940077  69309104807
## 6 1.322815e+10  11386850130  11861199831 1.301969e+10  15156432310  15401830754
```

```
##          X2020        X2021
## 1   2496648045           NA
## 2 921646000000 1.082100e+12
## 3  20116137326           NA
## 4 784446000000 8.358080e+11
## 5  53619071176 7.254699e+10
## 6  15131866271 1.826004e+10
```

Remove column 3 and 4 cause it is all the same value. All column 3 values are GDP *(current US$)* and column 4 values are *NY.GDP.MKTP.CD*.

```
global_gdp <- global_gdp %>%
               select(-c(3:4))
head(global_gdp)
```

```
##                  Country.Name Country.Code       X1960       X1961       X1962
## 1                       Aruba          ABW          NA          NA          NA
## 2 Africa Eastern and Southern          AFE 21290586003 21808473825 23707015394
## 3                 Afghanistan          AFG   537777811   548888896   546666678
## 4  Africa Western and Central          AFW 10404135069 11127894641 11943187848
## 5                      Angola          AGO          NA          NA          NA
## 6                     Albania          ALB          NA          NA          NA
##         X1963       X1964       X1965       X1966       X1967       X1968
## 1          NA          NA          NA          NA          NA          NA
## 2 28210036878 26118787467 29682172751 32239121547 33514552047 36521482937
## 3   751111191   800000044  1006666638  1399999967  1673333418  1373333367
## 4 12676330765 13838369295 14862225760 15832591204 14426038230 14880349280
## 5          NA          NA          NA          NA          NA          NA
## 6          NA          NA          NA          NA          NA          NA
##         X1969       X1970       X1971       X1972       X1973       X1974
## 1          NA          NA          NA          NA          NA          NA
## 2 41828336213 44862605393 49478916698 53514844534 69600788111 86057777551
## 3  1408888922  1748886596  1831108971  1595555476  1733333264  2155555498
## 4 16882092549 23504605476 20832817218 25264953766 31273819026 44214484997
## 5          NA          NA          NA          NA          NA          NA
## 6          NA          NA          NA          NA          NA          NA
##         X1975       X1976        X1977        X1978       X1979        X1980
```

```
## 1           NA           NA           NA           NA           NA           NA
## 2 91649152687 91124551926 103416000000 115345000000 1.34671e+11 170654000000
## 3  2366666616  2555555567   2953333418   3300000109 3.69794e+09   3641723322
## 4 51444731784 62129390375  65315008068  71199708192 8.86284e+10 112031000000
## 5           NA           NA           NA           NA           NA   5930503401
## 6           NA           NA           NA           NA           NA           NA
##          X1981        X1982        X1983        X1984       X1985        X1986
## 1           NA           NA           NA           NA          NA    405586592
## 2 174387000000 167266000000 174918000000 160134000000 1.36297e+11 152518000000
## 3   3478787909           NA           NA           NA          NA           NA
## 4 211003000000 187164000000 138115000000 114263000000 1.16507e+11 107498000000
## 5   5550483036   5550483036   5784341596   6131475065 7.55356e+09   7072063346
## 6           NA           NA           NA   1857338012 1.89705e+09   2097326250
##          X1987        X1988        X1989        X1990        X1991        X1992
## 1    487709497    596648045    695530726    764804469    872067039    958659218
## 2 186145000000 204140000000 217539000000 253224000000 273403000000 238255000000
## 3           NA           NA           NA           NA           NA           NA
## 4 110322000000 108943000000 101769000000 121802000000 117457000000 118282000000
## 5   8083872012   8769250550  10201099039  11228764963  10603784541   8307810974
## 6   2080796250   2051236250   2253090000   2028553750   1099559028    652174991
##          X1993        X1994        X1995        X1996        X1997        X1998
## 1   1083240223   1245810056   1320670391   1379888268   1531843575   1665363128
## 2 236527000000 240120000000 269637000000 268414000000 282185000000 265814000000
## 3           NA           NA           NA           NA           NA           NA
## 4  98826369836  86281743753 108221000000 125763000000 127064000000 130107000000
## 5   5768720422   4438321017   5538749260   7526446606   7648377413   6506229607
## 6   1185315468   1880951520   2392764853   3199641336   2258513974   2545964541
##          X1999        X2000        X2001        X2002        X2003        X2004
## 1   1722905028   1873184358   1896648045   1962011173   2044134078   2254748603
## 2 262172000000 283925000000 258819000000 264870000000 352659000000 438834000000
## 3           NA           NA           NA   4055179566   4515558808   5226778809
## 4 137521000000 140410000000 148013000000 176938000000 204645000000 254093000000
## 5   6152922943   9129594819   8936063723  15285594828  17812704825  23552047248
## 6   3212121651   3480355258   3922100794   4348068242   5611496257   7184685782
##          X2005        X2006        X2007        X2008        X2009        X2010
## 1   2359776536   2469832402   2677653631   2843016760   2553631285   2453631285
```

```
## 2 512211000000 575921000000 661179000000 708287000000 719217000000 860478000000
## 3   6209137625   6971285595   9747879532  10109305183  12416161049  15856678596
## 4 310558000000 393305000000 461791000000 566481000000 507044000000 591596000000
## 5  36970918699  52381006892  65266452081  88538610805  70307166934  81699556137
## 6   8052073539   8896072919  10677324144  12881353508  12044208086  11926922829
##          X2011        X2012        X2013        X2014        X2015        X2016
## 1   2637988827   2615083799   2727932961 2.791061e+09   2963128492   2983798883
## 2 964418000000 973043000000 983937000000 1.003680e+12 924253000000 882355000000
## 3  17805113119  19907317066  20146404996 2.049713e+10  19134211764  18116562465
## 4 670983000000 727570000000 820793000000 8.649900e+11 760734000000 690546000000
## 5 109437000000 124998000000 133402000000 1.372440e+11  87219290029  49840494026
## 6  12890764531  12319830437  12776220507 1.322815e+10  11386850130  11861199831
##          X2017        X2018        X2019        X2020        X2021
## 1 3.092179e+09   3202234637   3310055866   2496648045           NA
## 2 1.020650e+12 991022000000 997534000000 921646000000 1.082100e+12
## 3 1.875347e+10  18053228579  18799450743  20116137326           NA
## 4 6.837490e+11 741690000000 794543000000 784446000000 8.358080e+11
## 5 6.897276e+10  77792940077  69309104807  53619071176 7.254699e+10
## 6 1.301969e+10  15156432310  15401830754  15131866271 1.826004e+10
```

Change . in the header to *_* and remove X in front of years.

```
colnames(global_gdp) <- colnames(global_gdp) %>%
                        str_replace_all('\\.', '_') %>%
                        str_replace_all('X(?=\\d)', '')
head(global_gdp)
```

```
##                  Country_Name Country_Code        1960        1961        1962
## 1                       Aruba          ABW          NA          NA          NA
## 2 Africa Eastern and Southern          AFE 21290586003 21808473825 23707015394
## 3                 Afghanistan          AFG   537777811   548888896   546666678
## 4  Africa Western and Central          AFW 10404135069 11127894641 11943187848
## 5                      Angola          AGO          NA          NA          NA
## 6                     Albania          ALB          NA          NA          NA
##          1963        1964        1965        1966        1967        1968
## 1          NA          NA          NA          NA          NA          NA
## 2 28210036878 26118787467 29682172751 32239121547 33514552047 36521482937
```

```
## 3   751111191   800000044  1006666638  1399999967  1673333418  1373333367
## 4 12676330765 13838369295 14862225760 15832591204 14426038230 14880349280
## 5          NA          NA          NA          NA          NA          NA
## 6          NA          NA          NA          NA          NA          NA
##          1969        1970        1971        1972        1973        1974
## 1          NA          NA          NA          NA          NA          NA
## 2 41828336213 44862605393 49478916698 53514844534 69600788111 86057777551
## 3  1408888922  1748886596  1831108971  1595555476  1733333264  2155555498
## 4 16882092549 23504605476 20832817218 25264953766 31273819026 44214484997
## 5          NA          NA          NA          NA          NA          NA
## 6          NA          NA          NA          NA          NA          NA
##          1975        1976         1977         1978        1979         1980
## 1          NA          NA           NA           NA          NA           NA
## 2 91649152687 91124551926 103416000000 115345000000 1.34671e+11 170654000000
## 3  2366666616  2555555567   2953333418   3300000109 3.69794e+09   3641723322
## 4 51444731784 62129390375  65315008068  71199708192 8.86284e+10 112031000000
## 5          NA          NA           NA           NA          NA   5930503401
## 6          NA          NA           NA           NA          NA           NA
##          1981         1982         1983         1984        1985         1986
## 1          NA           NA           NA           NA          NA    405586592
## 2 174387000000 167266000000 174918000000 160134000000 1.36297e+11 152518000000
## 3   3478787909           NA           NA           NA          NA           NA
## 4 211003000000 187164000000 138115000000 114263000000 1.16507e+11 107498000000
## 5   5550483036   5550483036   5784341596   6131475065 7.55356e+09   7072063346
## 6          NA           NA           NA   1857338012 1.89705e+09   2097326250
##          1987         1988         1989         1990         1991         1992
## 1    487709497    596648045    695530726    764804469    872067039    958659218
## 2 186145000000 204140000000 217539000000 253224000000 273403000000 238255000000
## 3          NA           NA           NA           NA           NA           NA
## 4 110322000000 108943000000 101769000000 121802000000 117457000000 118282000000
## 5   8083872012   8769250550  10201099039  11228764963  10603784541   8307810974
## 6   2080796250   2051236250   2253090000   2028553750   1099559028    652174991
##          1993         1994         1995         1996         1997         1998
## 1   1083240223   1245810056   1320670391   1379888268   1531843575   1665363128
## 2 236527000000 240120000000 269637000000 268414000000 282185000000 265814000000
## 3          NA           NA           NA           NA           NA           NA
```

```
## 4  98826369836  86281743753 108221000000 125763000000 127064000000 130107000000
## 5   5768720422   4438321017   5538749260   7526446606   7648377413   6506229607
## 6   1185315468   1880951520   2392764853   3199641336   2258513974   2545964541
##           1999         2000         2001         2002         2003         2004
## 1   1722905028   1873184358   1896648045   1962011173   2044134078   2254748603
## 2 262172000000 283925000000 258819000000 264870000000 352659000000 438834000000
## 3           NA           NA           NA   4055179566   4515558808   5226778809
## 4 137521000000 140410000000 148013000000 176938000000 204645000000 254093000000
## 5   6152922943   9129594819   8936063723  15285594828  17812704825  23552047248
## 6   3212121651   3480355258   3922100794   4348068242   5611496257   7184685782
##           2005         2006         2007         2008         2009         2010
## 1   2359776536   2469832402   2677653631   2843016760   2553631285   2453631285
## 2 512211000000 575921000000 661179000000 708287000000 719217000000 860478000000
## 3   6209137625   6971285595   9747879532  10109305183  12416161049  15856678596
## 4 310558000000 393305000000 461791000000 566481000000 507044000000 591596000000
## 5  36970918699  52381006892  65266452081  88538610805  70307166934  81699556137
## 6   8052073539   8896072919  10677324144  12881353508  12044208086  11926922829
##           2011         2012         2013         2014         2015         2016
## 1   2637988827   2615083799   2727932961 2.791061e+09   2963128492   2983798883
## 2 964418000000 973043000000 983937000000 1.003680e+12 924253000000 882355000000
## 3  17805113119  19907317066  20146404996 2.049713e+10  19134211764  18116562465
## 4 670983000000 727570000000 820793000000 8.649900e+11 760734000000 690546000000
## 5 109437000000 124998000000 133402000000 1.372440e+11  87219290029  49840494026
## 6  12890764531  12319830437  12776220507 1.322815e+10  11386850130  11861199831
##           2017         2018         2019         2020         2021
## 1 3.092179e+09   3202234637   3310055866   2496648045           NA
## 2 1.020650e+12 991022000000 997534000000 921646000000 1.082100e+12
## 3 1.875347e+10  18053228579  18799450743  20116137326           NA
## 4 6.837490e+11 741690000000 794543000000 784446000000 8.358080e+11
## 5 6.897276e+10  77792940077  69309104807  53619071176 7.254699e+10
## 6 1.301969e+10  15156432310  15401830754  15131866271 1.826004e+10
```

```
tail(global_gdp)
```

```
##     Country_Name Country_Code       1960       1961       1962       1963
## 261        Samoa          WSM         NA         NA         NA         NA
## 262       Kosovo          XKX         NA         NA         NA         NA
```

```
## 263  Yemen, Rep.          YEM         NA         NA         NA          NA
## 264 South Africa          ZAF 8748596504 9225996313 9813996079 10854195663
## 265       Zambia          ZMB  713000000  696285714  693142857   718714286
## 266     Zimbabwe          ZWE 1052990400 1096646600 1117601600  1159511700
##            1964        1965        1966        1967        1968        1969
## 261          NA          NA          NA          NA          NA          NA
## 262          NA          NA          NA          NA          NA          NA
## 263          NA          NA          NA          NA          NA          NA
## 264 11955995223 13068994778 14211394321 15821393678 17124793157 19256992305
## 265   839428571  1082857143  1264285714  1368000000  1605857143  1965714286
## 266  1217138000  1311435800  1281749500  1397002000  1479599900  1747998800
##            1970        1971        1972        1973        1974        1975
## 261          NA          NA          NA          NA          NA          NA
## 262          NA          NA          NA          NA          NA          NA
## 263          NA          NA          NA          NA          NA          NA
## 264 21218391522 23411079378 24515911652 33262767311 41389185875 42906919870
## 265  1825285714  1687000000  1910714286  2268714286  3121833333  2618666667
## 266  1884206300  2178716300  2677729400  3309353600  3982161400  4371300700
##            1976        1977        1978        1979        1980        1981
## 261          NA          NA          NA          NA          NA          NA
## 262          NA          NA          NA          NA          NA          NA
## 263          NA          NA          NA          NA          NA          NA
## 264 41150449966 45328399963 51607399958 63038687893 89411894561 93141478235
## 265  2746714286  2483000000  2813375000  3325500000  3829500000  3872666667
## 266  4318372000  4364382100  4351600500  5177459400  6678868200  8011373800
##            1982        1983        1984        1985        1986        1987
## 261   121221652   111862824   109200934    95572173   100947849   111713922
## 262          NA          NA          NA          NA          NA          NA
## 263          NA          NA          NA          NA          NA          NA
## 264 85904070614 96204110959 84870134619 64459376104 73354782109 96535747615
## 265  3994777778  3216307692  2739444444  2281258065  1661948718  2269894737
## 266  8539700700  7764067000  6352125900  5637259300  6217523700  6741215100
##            1988        1989        1990        1991        1992
## 261   133016065   122888610   125766270   125597205   132303041
## 262          NA          NA          NA          NA          NA
## 263          NA          NA  5647119229  5930370370  6463649985
```

```
## 264 103977000000 108056000000 126048000000 135204000000 146957000000
## 265   3713614458   3998637681   3285217391   3378882353   3181921788
## 266   7814784100   8286322700   8783816700   8641481700   6751472200
##             1993         1994         1995         1996         1997
## 261    133122897    221098106    224865731    249908971    285475592
## 262           NA           NA           NA           NA           NA
## 263   5368270615   4167356037   4258788725   5785685311   6838557384
## 264 147197000000 153513000000 171735000000 163237000000 168977000000
## 265   3273237853   3656647744   3807067122   3597220962   4303281932
## 266   6563813300   6890675000   7111270700   8553146600   8529571600
##             1998         1999         2000         2001         2002
## 261    269481523    255410025    258856139    266299604    281793615
## 262           NA           NA           NA           NA           NA
## 263   6325141676   7641102523   9652436180   9861560095  10694628092
## 264 152983000000 151517000000 151753000000 135430000000 129088000000
## 265   3537683046   3404311977   3600683040   4094480988   4193845678
## 266   6401968200   6858013100   6689957600   6777384700   6342116400
##             2003         2004         2005         2006         2007
## 261    333428714    407749577    476801791    499923741    573548460
## 262           NA           NA           NA           NA           NA
## 263  11777966673  13872791659  16746344766  19061978586  21650532264
## 264 197020000000 255807000000 288868000000 303861000000 333075000000
## 265   4901839731   6221077675   8331870169  12756858899  14056957976
## 266   5727591800   5805598400   5755215200   5443896500   5291950100
##             2008         2009         2010         2011         2012
## 261    641346175    628006123    663161528    737401684    760549578
## 262   5181776769   5015894693   5344014318   6341737194   6163785173
## 263  26910851362  25130274124  30906749533  32726417212  35401341663
## 264 316132000000 329753000000 417365000000 458202000000 434401000000
## 265  17910858638  15328342304  20265559484  23459515276  25503060420
## 266   4415702800   9665793300  12041655200  14101920300  17114849900
##             2013         2014         2015         2016         2017
## 261    770059565    756805950    788307315    799493898    832025556
## 262   6735731173   7074657898   6295820482   6682832632   7180813376
## 263  40415235702  43228585321  42444495590  31317828584  26842231205
## 264 400886000000 381199000000 346710000000 323586000000 381449000000
```

```
## 265  28037239463  27141023558  21251216799  20958412538  25873601261
## 266  19091020000  19495519600  19963120600  20548678100  17584890937
##             2018         2019         2020         2021
## 261    821286939    852007105    807147528    788389972
## 262   7878508503   7899879086   7716925356   9007159196
## 263  21606161066  21887614217  18840511908  21061691630
## 264 404842000000 387935000000 335442000000 419946000000
## 265  26311590297  23308667781  18110631358  21203059080
## 266  18115543791  19284289739  18051170799  26217726717
```

Transfer into a tidy data frame. Use *pivot_longer( )* function to pivot from column 3 *1960* to last column *2021*. Exclude cell with NA value while pivoting.

```
global_gdp_longer <- global_gdp %>%
                        pivot_longer(
                          cols = colnames(global_gdp)[-c(1,2)],
                          names_to = 'Year',
                          values_to = 'GDP',
                          values_drop_na = TRUE
                        )
head(global_gdp_longer)
```

```
## # A tibble: 6 x 4
##   Country_Name Country_Code Year         GDP
##   <chr>        <chr>        <chr>      <dbl>
## 1 Aruba        ABW          1986  405586592.
## 2 Aruba        ABW          1987  487709497.
## 3 Aruba        ABW          1988  596648045.
## 4 Aruba        ABW          1989  695530726.
## 5 Aruba        ABW          1990  764804469.
## 6 Aruba        ABW          1991  872067039.
```

```
tail(global_gdp_longer)
```

```
## # A tibble: 6 x 4
##   Country_Name Country_Code Year          GDP
##   <chr>        <chr>        <chr>       <dbl>
## 1 Zimbabwe     ZWE          2016  20548678100
```

```
## 2 Zimbabwe     ZWE          2017  17584890937
## 3 Zimbabwe     ZWE          2018  18115543791
## 4 Zimbabwe     ZWE          2019  19284289739
## 5 Zimbabwe     ZWE          2020  18051170799
## 6 Zimbabwe     ZWE          2021  26217726717
```

Convert *Year* data type; Character to double.

```
global_gdp_longer$Year = as.numeric(global_gdp_longer$Year)
```

Calculate the growth rate for each country.

```
global_gdp_longer <- global_gdp_longer %>%
  group_by(Country_Code) %>%
    mutate(
      Prev_10_GDP = ifelse(is.na(lag(GDP, n = 10)), 0, lag(GDP, n = 10)),
#      Prev_GDP = ifelse(is.na(lag(GDP)), 0, lag(GDP)),
#      Diff_GDP = GDP - lag(GDP),
#      Rate_percent = round((GDP / lag(GDP) - 1) * 100, digits = 2)
      Diff_growth = ifelse(is.na(lag(GDP)), 0, GDP - lag(GDP)),
      Rate_percent = ifelse(is.na(lag(GDP)), 0, round((GDP / lag(GDP) - 1) * 100, digits = 2))
    )
global_gdp_longer
```

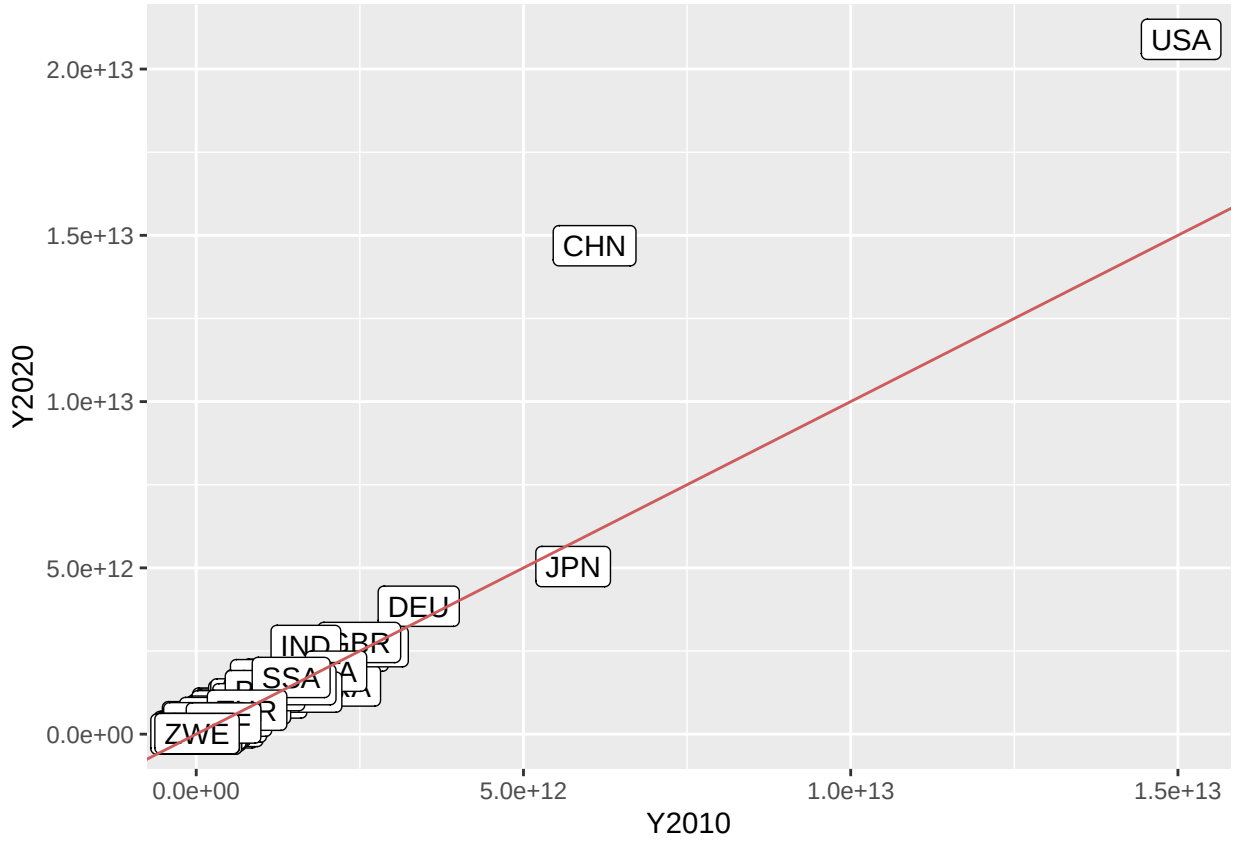
```
## # A tibble: 13,118 x 7
## # Groups:   Country_Code [262]
##    Country_Name Country_Code  Year         GDP Prev_10_GDP Diff_growth Rate_pe~1
##    <chr>        <chr>        <dbl>       <dbl>       <dbl>       <dbl>     <dbl>
##  1 Aruba        ABW           1986  405586592.           0           0       0
##  2 Aruba        ABW           1987  487709497.           0    82122905      20.2
##  3 Aruba        ABW           1988  596648045.           0   108938548.     22.3
##  4 Aruba        ABW           1989  695530726.           0    98882682.     16.6
##  5 Aruba        ABW           1990  764804469.           0    69273743       9.96
##  6 Aruba        ABW           1991  872067039.           0   107262570.     14.0
##  7 Aruba        ABW           1992  958659218.           0    86592179.      9.93
##  8 Aruba        ABW           1993 1083240223           0   124581005.     13
##  9 Aruba        ABW           1994 1245810056           0   162569833      15.0
```

```
## 10 Aruba        ABW           1995 1320670391            0   74860335       6.01
## # ... with 13,108 more rows, and abbreviated variable name 1: Rate_percent
```

Compare 2010 and 2020. The graph shows the GDP of developed countries continued to rise over time. Especially, the USA and China's GDP grew strongly. However, underdeveloped countries did not grow.

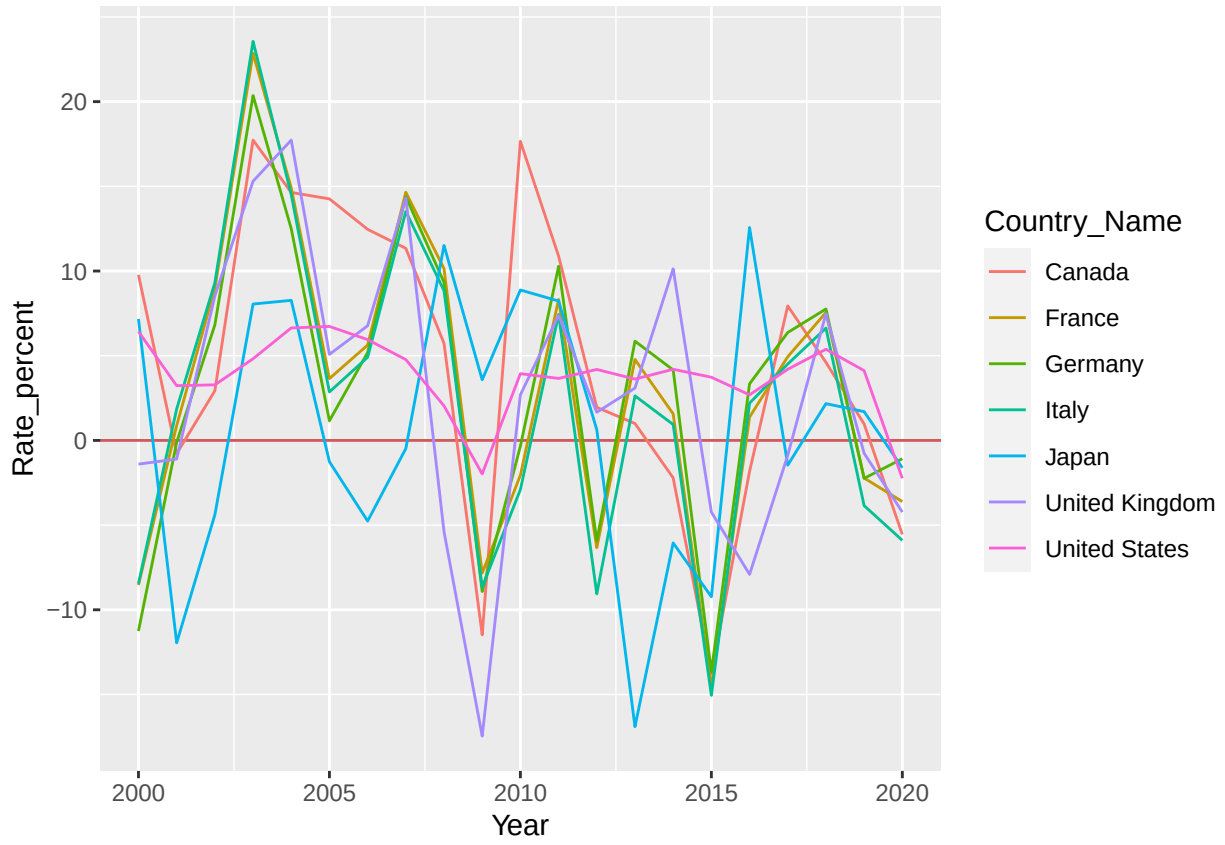
```
exclude <- c('WLD', 'OED', 'PST', 'EAP', 'EAR', 'EAS', 'ECA', 'ECS', 'FCS', 'HPC',
             'UMC', 'EUU', 'EMU', 'LMC', 'TLA', 'TEA', 'HIC', 'NAC', 'IBT', 'MIC',
             'LTE', 'LMY', 'LCN', 'LDC', 'TEC', 'TSA', 'TMN', 'TSS', 'IBD', 'LAC',
             'SAS', 'MEA', 'SSF')
global_gdp_longer %>%
  filter(Year == 2020, !(Country_Code %in% exclude)) %>%
  ggplot(aes(x = Prev_10_GDP, y = GDP, label = Country_Code), color = 'SteelBlue') +
  geom_point() +
  geom_label(
    nudge_x = 0.25, nudge_y = 0.25,
    check_overlap = T
  ) +
  geom_abline(intercept = 0, slope = 1, size = 0.5, color = 'IndianRed') +
  labs(
    x = 'Y2010',
    y = 'Y2020'
  )
```

```
## Warning: Ignoring unknown parameters: check_overlap
```

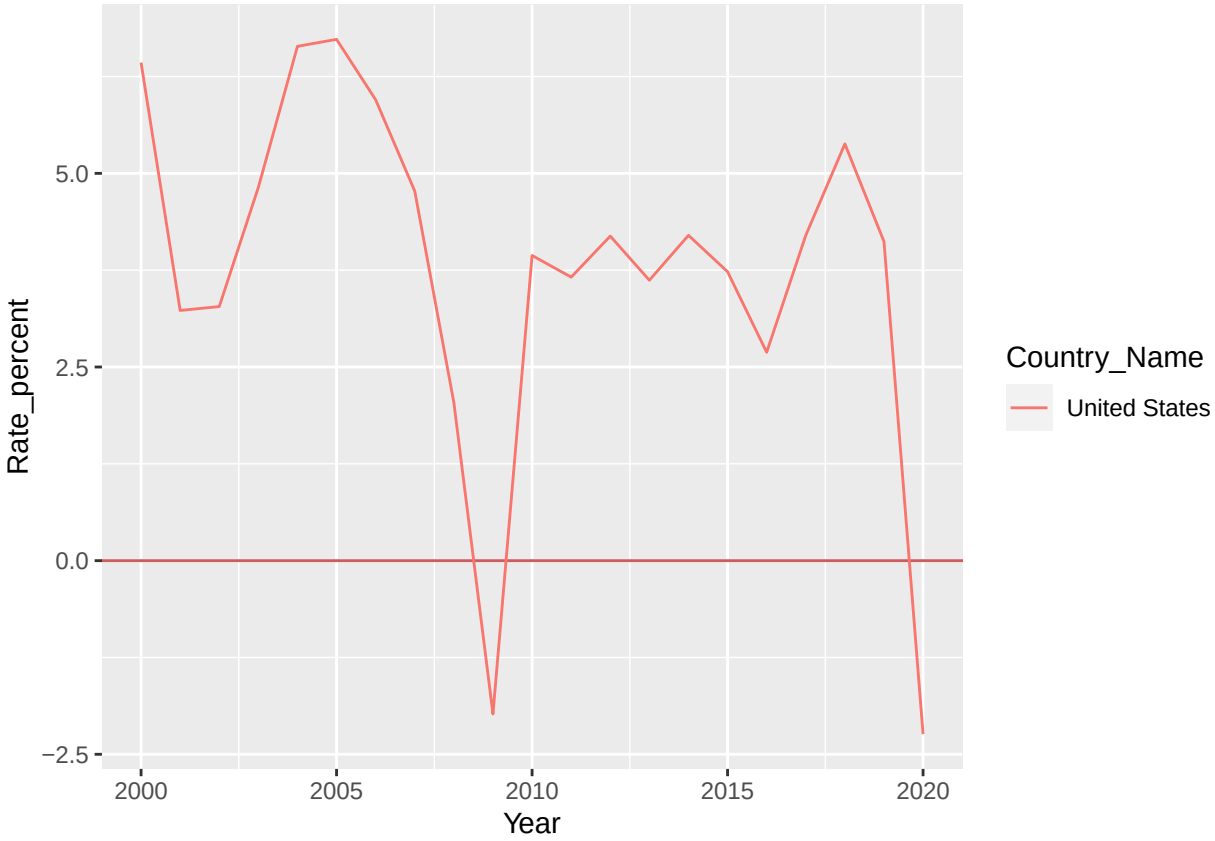


Compare GDP growth for G7 country in a 10-year cycle. In 2008 there was the subprime mortgage crisis, and in 2020 there was the corona virus pandemic.

```
#DEU: Germany, GBR: the United Kingdom
G7 <- c('CAN', 'FRA', 'DEU', 'ITA', 'JPN', 'GBR', 'USA')
global_gdp_longer %>%
  filter(Country_Code %in% G7, Year > 1999, Year < 2021) %>%
  ggplot(aes(x = Year, y = Rate_percent, color = Country_Name)) +
    geom_abline(intercept = 0, slope = 0, size = 0.5, color = 'IndianRed')+
      geom_line() +
      labs(
        x = 'Year',
        y = 'Rate_percent'
      )
```




```
#DEU: Germany, GBR: the United Kingdom
G7 <- c('USA')
global_gdp_longer %>%
  filter(Country_Code %in% G7, Year > 1999, Year < 2021) %>%
  ggplot(aes(x = Year, y = Rate_percent, color = Country_Name)) +
    geom_abline(intercept = 0, slope = 0, size = 0.5, color = 'IndianRed')+
      geom_line() +
      labs(
        x = 'Year',
        y = 'Rate_percent'
      )
```



- GitHub - https://github.com/blacksmilez/DATA607/tree/main/Project2
- RPubs - https://rpubs.com/blacksmilez/953864