

Data Wrangling (3)

Reshape and Combine Tables (con'd)

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Setup

Reshape a
Table

Stack Tables

Join Tables

Setup

- ▶ Reshape (long \leftrightarrow wide) with `pivot_longer` and `pivot_wider`
- ▶ Stack tables by row or by column with `bind_rows` and `bind_cols` (or, alternatively, `cbind` and `rbind`)
- ▶ Merge two tables with `inner_join`, `full_join`, `left_join`, `right_join`, `semi_join`, and `anti_join`

Example: The V-Dem Data

```
library(tidyverse)
d <- read_csv("_DataPublic_/vdem/1984_2022/vdem_1984_2022_external.csv")
d |> print(n = 3)

## # A tibble: 6,789 x 211
##   country_name country_text_id country_id year historical_date project
##   <chr>         <chr>             <dbl> <dbl> <date>             <dbl>
## 1 Mexico       MEX                 3  1984 1984-12-31             0
## 2 Mexico       MEX                 3  1985 1985-12-31             0
## 3 Mexico       MEX                 3  1986 1986-12-31             0
## # i 6,786 more rows
## # i 205 more variables: historical <dbl>, histname <chr>, codingstart <dbl>,
## #   codingend <dbl>, codingstart_contemp <dbl>, codingend_contemp <dbl>,
## #   codingstart_hist <dbl>, codingend_hist <dbl>, gapstart1 <dbl>,
## #   gapstart2 <dbl>, gapstart3 <dbl>, gapend1 <dbl>, gapend2 <dbl>,
## #   gapend3 <dbl>, gap_index <dbl>, COWcode <dbl>, e_v2x_api_3C <dbl>,
## #   e_v2x_api_4C <dbl>, e_v2x_api_5C <dbl>, e_v2x_civlib_3C <dbl>, ...
```

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Example: The V-Dem Data

Focus on the economic indicators: GDP and GDP per capita.

```
d_gdp <- d |>
  select(country_text_id, year, e_gdp, e_gdppc) |>
  rename("gdp" = "e_gdp", "gdppc" = "e_gdppc")

d_gdp |> print(n = 3)
```

```
## # A tibble: 6,789 x 4
##   country_text_id year    gdp gdppc
##   <chr>          <dbl> <dbl> <dbl>
## 1 MEX            1984 93563.  11.7
## 2 MEX            1985 94259.  11.5
## 3 MEX            1986 92750.  11.1
## # i 6,786 more rows
```

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Reshape a Table

Wide to Long: pivot_longer

```
d_gdp_long <- d_gdp |>  
  pivot_longer(cols = c("gdp", "gdppc"),  
               names_to = "variable", values_to = "value")
```

```
d_gdp_long |> print(n = 4)
```

```
## # A tibble: 13,578 x 4  
##   country_text_id year variable    value  
##   <chr>          <dbl> <chr>    <dbl>  
## 1 MEX            1984 gdp      93563.  
## 2 MEX            1984 gdppc      11.7  
## 3 MEX            1985 gdp      94259.  
## 4 MEX            1985 gdppc      11.5  
## # i 13,574 more rows
```

Long to Wide: pivot_wider

Task: Reverse the above pivot_long operation.

```
d_gdp_wide_1 <- d_gdp_long |>  
  pivot_wider(names_from = "variable", values_from = "value")
```

```
d_gdp_wide_1 |> print(n = 4)
```

```
## # A tibble: 6,789 x 4  
##   country_text_id year    gdp gdppc  
##   <chr>          <dbl> <dbl> <dbl>  
## 1 MEX            1984 93563.  11.7  
## 2 MEX            1985 94259.  11.5  
## 3 MEX            1986 92750.  11.1  
## 4 MEX            1987 93220.  10.9  
## # i 6,785 more rows
```

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Long to Wide: pivot_wider

Task: Make `year` the column variable.

```
d_gdp_wide_2 <- d_gdp_long |>  
  pivot_wider(names_from = "year", values_from = "value")  
  
d_gdp_wide_2 |> print(n = 2)
```

```
## # A tibble: 362 x 41  
##   country_text_id variable `1984` `1985` `1986` `1987` `1988` `1989` `1990`  
##   <chr>           <chr>    <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  
## 1 MEX             gdp      93563.  94259.  92750.  93220.  94687.  9.81e4 1.03e5  
## 2 MEX             gdppc      11.7    11.5    11.1    10.9    10.8  1.10e1 1.14e1  
## # i 360 more rows  
## # i 32 more variables: `1991` <dbl>, `1992` <dbl>, `1993` <dbl>, `1994` <dbl>,  
## #   `1995` <dbl>, `1996` <dbl>, `1997` <dbl>, `1998` <dbl>, `1999` <dbl>,  
## #   `2000` <dbl>, `2001` <dbl>, `2002` <dbl>, `2003` <dbl>, `2004` <dbl>,  
## #   `2005` <dbl>, `2006` <dbl>, `2007` <dbl>, `2008` <dbl>, `2009` <dbl>,  
## #   `2010` <dbl>, `2011` <dbl>, `2012` <dbl>, `2013` <dbl>, `2014` <dbl>,  
## #   `2015` <dbl>, `2016` <dbl>, `2017` <dbl>, `2018` <dbl>, `2019` <dbl>, ...
```

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Long to Wide: pivot_wider

Task: Make country_text_id the column variable.

```
d_gdp_wide_3 <- d_gdp_long |>  
  pivot_wider(names_from = "country_text_id", values_from = "value")  
  
d_gdp_wide_3 |> print(n = 2)
```

```
## # A tibble: 78 x 183  
##   year variable      MEX      SUR      SWE      CHE      GHA      ZAF      JPN      MMR      RUS  
##   <dbl> <chr>      <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>  
## 1 1984 gdp      93563. 286. 2.35e4 2.31e4 3.02e3 3.15e4 2.87e5 4.18e3 3.49e5  
## 2 1984 gdppc      11.7 7.43 2.66e1 3.32e1 2.20e0 9.03e0 2.26e1 1.10e0 1.65e1  
## # i 76 more rows  
## # i 172 more variables: ALB <dbl>, EGY <dbl>, YEM <dbl>, COL <dbl>, POL <dbl>,  
## #   BRA <dbl>, USA <dbl>, PRT <dbl>, SLV <dbl>, YMD <dbl>, BGD <dbl>,  
## #   BOL <dbl>, HTI <dbl>, HND <dbl>, MLI <dbl>, PAK <dbl>, PER <dbl>,  
## #   SEN <dbl>, SSD <dbl>, SDN <dbl>, VNM <dbl>, AFG <dbl>, ARG <dbl>,  
## #   ETH <dbl>, IND <dbl>, KEN <dbl>, PRK <dbl>, KOR <dbl>, XKX <dbl>,  
## #   LBN <dbl>, NGA <dbl>, PHL <dbl>, TZA <dbl>, TWN <dbl>, THA <dbl>, ...
```

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Why Do We Reshape Data?

- ▶ **For data cleaning:** Sometime it is much easier to clean the data after reshaping
- ▶ **For data visualization:** Some data visualization functions only take tables shaped in a specific way
- ▶ **For data sharing:** Sometimes you want to export the data for human readers (e.g., data coding/ labeling)

“But I am sure Excel can do the same thing!” It can do it for HUGE data reliably and fast. And the process is replicable.

Stack Tables

- ▶ Let's say we want to merge your GDP data `d_gdp` with some additional datasets that *you know* you can just safely stack together.
- ▶ Example
 - ▶ Merge with GDP data from 1906 to 1983
 - ▶ Merge with education and Freedom House data from 1984 to 2022

Housekeeping: Load New Data

To demonstrate how to stack data vertically, I make a table with GDP data from two previous time periods (1945 to 1983 and 1906-1944).

```
d_gdp_1945 <-  
  read_csv("_DataPublic_/vdem/1945_1983/vdem_1945_1983_external.csv") |>  
  select(country_text_id, year, e_gdp, e_gdppc) |>  
  rename("gdp" = "e_gdp", "gdppc" = "e_gdppc")  
  
d_gdp_1906 <-  
  read_csv("_DataPublic_/vdem/1906_1944/vdem_1906_1944_external.csv") |>  
  select(country_text_id, year, e_gdp, e_gdppc) |>  
  rename("gdp" = "e_gdp", "gdppc" = "e_gdppc")  
  
d_gdp_1945 |> print(n = 2)
```

```
## # A tibble: 6,082 x 4  
##   country_text_id year    gdp gdppc  
##   <chr>          <dbl> <dbl> <dbl>  
## 1 MEX              1945 7827.  3.08  
## 2 MEX              1946 8331.  3.17  
## # i 6,080 more rows
```

Housekeeping: Load New Data

To demonstrate how to stack data horizontally, I make two subsets of `d` — one with education indicators, another with Freedom House indicators.

```
d_edu <- d |>
  select(e_peaveduc, e_peedgini) |>
  rename("edu_15" = "e_peaveduc", "edu_gini" = "e_peedgini")

d_fh <- d |>
  select(starts_with("e_fh")) |>
  rename("fh_CivilLiberty" = "e_fh_cl", "fh_PoliticalRight" = "e_fh_pr",
        "fh_RuleOfLaw" = "e_fh_rol", "fh_Status" = "e_fh_status")

d_fh |> print(n = 2)
```

```
## # A tibble: 6,789 x 4
##   fh_CivilLiberty fh_PoliticalRight fh_RuleOfLaw fh_Status
##           <dbl>           <dbl>         <dbl>     <dbl>
## 1             4             3             NA         2
## 2             4             4             NA         2
## # i 6,787 more rows
```

bind_rows

```
d_gdp_1945_2022 <- bind_rows(d_gdp, d_gdp_1945)
d_gdp_1945_2022 |> print(n = 3)
```

```
## # A tibble: 12,871 x 4
##   country_text_id year      gdp gdppc
##   <chr>          <dbl>  <dbl> <dbl>
## 1 MEX            1984 93563.  11.7
## 2 MEX            1985 94259.  11.5
## 3 MEX            1986 92750.  11.1
## # i 12,868 more rows
```

```
unique(d_gdp_1945_2022$year) |> sort()
```

```
## [1] 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959
## [16] 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974
## [31] 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989
## [46] 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
## [61] 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
## [76] 2020 2021 2022
```


bind_rows

```
d_gdp_1906_2022 <- bind_rows(d_gdp, d_gdp_1945, d_gdp_1906) # can take multiple data frames
d_gdp_1906_2022 |> print(n = 3)
```

```
## # A tibble: 18,559 x 4
##   country_text_id year   gdp gdppc
##   <chr>          <dbl> <dbl> <dbl>
## 1 MEX             1984 93563.  11.7
## 2 MEX             1985 94259.  11.5
## 3 MEX             1986 92750.  11.1
## # i 18,556 more rows
```

```
unique(d_gdp_1906_2022$year) |> sort()
```

```
##   [1] 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920
##  [16] 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935
##  [31] 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950
##  [46] 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965
##  [61] 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980
##  [76] 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995
##  [91] 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
## [106] 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022
```

bind_cols

```
d_gdp_edu_fh <- bind_cols(d_gdp, d_edu, d_fh) # can take multiple data frames
d_gdp_edu_fh |> print(n = 3)
```

```
## # A tibble: 6,789 x 10
##   country_text_id year    gdp gdppc edu_15 edu_gini fh_CivilLiberty
##   <chr>          <dbl> <dbl> <dbl> <dbl>    <dbl>        <dbl>
## 1 MEX              1984 93563.  11.7   6.08     32.7          4
## 2 MEX              1985 94259.  11.5   6.22     32.4          4
## 3 MEX              1986 92750.  11.1   6.36     31.9          4
## # i 6,786 more rows
## # i 3 more variables: fh_PoliticalRight <dbl>, fh_RuleOfLaw <dbl>,
## #   fh_Status <dbl>
```

```
names(d_gdp_edu_fh)
```

```
## [1] "country_text_id" "year" "gdp"
## [4] "gdppc" "edu_15" "edu_gini"
## [7] "fh_CivilLiberty" "fh_PoliticalRight" "fh_RuleOfLaw"
## [10] "fh_Status"
```

!! WARNING !!

These are error-prone operations

- ▶ Do `bind_rows` and `bind_cols` ONLY WHEN you know for sure that there will not be a mismatch!
- ▶ If you have any slightest doubt, don't use them.

Join Tables

Understand the behavior of different `join_` functions

- ▶ `left_join`: Merge and only keep observations that appear in the left-hand-side table.
- ▶ `right_join`: Merge and only keep observations that appear in the right-hand-side table.
- ▶ `inner_join`: Merge and only keep observations that appear in both tables.
- ▶ `full_join`: Merge and keep observations that appear either table.
- ▶ `anti_join`: Filter out observations that does appears in the right-hand-side table
- ▶ `semi_join`: Filter out observations that does not appear in the right-hand-side table

Task 1: The Case

Join two datasets from the V-Dem data using the above different `join_` functions

- ▶ *GDP* data from 2000-2022
- ▶ *GDP per capita* data from 1984 to 2010

Task 1: Setup

```
d_gdp_2000_2022 <- d |> filter(year %in% 2000:2022) |>
  select(country_text_id, year, e_gdp) |> rename("gdp" = "e_gdp")

d_gdppc_1984_2010 <- d |> filter(year %in% 1984:2010) |>
  select(country_text_id, year, e_gdppc) |> rename("gdppc" = "e_gdppc")

d_gdp_2000_2022 |> print(n = 2)
```

```
## # A tibble: 4,099 x 3
##   country_text_id year    gdp
##   <chr>          <dbl>  <dbl>
## 1 MEX            2000 145206.
## 2 MEX            2001 146993.
## # i 4,097 more rows
```

```
d_gdppc_1984_2010 |> print(n = 2)
```

```
## # A tibble: 4,641 x 3
##   country_text_id year  gdppc
##   <chr>          <dbl> <dbl>
## 1 MEX            1984   11.7
## 2 MEX            1985   11.5
## # i 4,639 more rows
```

left_join

```
d_lj <- d_gdp_2000_2022 |>  
  left_join(d_gdppc_1984_2010, by = c("country_text_id", "year"))
```

```
d_lj |> print(n = 2)
```

```
## # A tibble: 4,099 x 4  
##   country_text_id year      gdp gdppc  
##   <chr>          <dbl>   <dbl> <dbl>  
## 1 MEX            2000 145206.  13.7  
## 2 MEX            2001 146993.  13.6  
## # i 4,097 more rows
```

```
unique(d_lj$year) |> sort()
```

```
## [1] 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014  
## [16] 2015 2016 2017 2018 2019 2020 2021 2022
```

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right_join

```
d_rj <- d_gdp_2000_2022 |>  
  right_join(d_gdppc_1984_2010, by = c("country_text_id", "year"))
```

```
d_rj |> print(n = 2)
```

```
## # A tibble: 4,641 x 4  
##   country_text_id year      gdp gdppc  
##   <chr>          <dbl>   <dbl> <dbl>  
## 1 MEX            2000 145206.  13.7  
## 2 MEX            2001 146993.  13.6  
## # i 4,639 more rows
```

```
unique(d_rj$year) |> sort()
```

```
## [1] 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998  
## [16] 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
```

inner_join

```
d_ij <- d_gdp_2000_2022 |>  
  inner_join(d_gdppc_1984_2010, by = c("country_text_id", "year"))
```

```
d_ij |> print(n = 2)
```

```
## # A tibble: 1,951 x 4  
##   country_text_id year      gdp gdppc  
##   <chr>          <dbl>   <dbl> <dbl>  
## 1 MEX            2000 145206.  13.7  
## 2 MEX            2001 146993.  13.6  
## # i 1,949 more rows
```

```
unique(d_ij$year) |> sort()
```

```
## [1] 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
```

full_join

```
d_fj <- d_gdp_2000_2022 |>  
  full_join(d_gdppc_1984_2010, by = c("country_text_id", "year"))
```

```
d_fj |> print(n = 2)
```

```
## # A tibble: 6,789 x 4  
##   country_text_id year      gdp gdppc  
##   <chr>          <dbl>   <dbl> <dbl>  
## 1 MEX            2000 145206.  13.7  
## 2 MEX            2001 146993.  13.6  
## # i 6,787 more rows
```

```
unique(d_fj$year) |> sort()
```

```
## [1] 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998  
## [16] 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013  
## [31] 2014 2015 2016 2017 2018 2019 2020 2021 2022
```

semi_join

```
d_sj <- d_gdp_2000_2022 |>  
  semi_join(d_gdppc_1984_2010, by = c("country_text_id", "year"))
```

```
d_sj |> print(n = 2)
```

```
## # A tibble: 1,951 x 3  
##   country_text_id year      gdp  
##   <chr>          <dbl>   <dbl>  
## 1 MEX            2000 145206.  
## 2 MEX            2001 146993.  
## # i 1,949 more rows
```

```
unique(d_sj$year) |> sort()
```

```
## [1] 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
```

anti_join

```
d_aj <- d_gdp_2000_2022 |>  
  anti_join(d_gdppc_1984_2010, by = c("country_text_id", "year"))
```

```
d_aj |> print(n = 2)
```

```
## # A tibble: 2,148 x 3  
##   country_text_id year      gdp  
##   <chr>          <dbl>   <dbl>  
## 1 MEX            2011 185824.  
## 2 MEX            2012 192272.  
## # i 2,146 more rows
```

```
unique(d_aj$year) |> sort()
```

```
## [1] 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022
```

Join by Identifiers with Different Variable Names

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If the identifiers have different names, you have two options: (1) Rename it beforehand, (2) specify the `by =` argument differently.

```
# I make an artificial example whose variable name of a matching  
# identifier is different from d_gdp_2020_2022.  
d_gdppc_1984_2010_t <- d_gdppc_1984_2010 |>  
  rename("country_id" = "country_text_id")
```

```
# Option 1: Rename the variables beforehand  
d_aj_t <- d_gdp_2000_2022 |>  
  rename("country_id" = "country_text_id") |>  
  anti_join(d_gdppc_1984_2010_t, by = c("country_id", "year"))
```

```
# Option 2: Specify the "by =" argument with a *named vector*  
d_aj_t_2 <- d_gdp_2000_2022 |>  
  anti_join(d_gdppc_1984_2010_t,  
    by = c("country_text_id" = "country_id",  
          "year" = "year"))
```

Many-to-One Join: Repeat!

Calculate each country's average 1984-2010 *GDP per capita* and merge it with our annual GDP data from 2000 to 2022.

```
d_gdppc_1984_2010_avg <- d_gdppc_1984_2010 |> group_by(country_text_id) |>
  summarise(gdppc_1984to2010 = mean(gdppc, na.rm = TRUE))
d_gdppc_1984_2010_avg |> print(n = 2)
```

```
## # A tibble: 180 x 2
##   country_text_id gdppc_1984to2010
##   <chr>          <dbl>
## 1 AFG             1.22
## 2 AGO             3.35
## # i 178 more rows
```

```
d_lj_ManyToOne <- d_gdp_2000_2022 |>
  left_join(d_gdppc_1984_2010_avg, by = "country_text_id")
d_lj_ManyToOne |> print(n = 2)
```

```
## # A tibble: 4,099 x 4
##   country_text_id year      gdp gdppc_1984to2010
##   <chr>          <dbl>   <dbl>          <dbl>
## 1 MEX             2000 145206.            12.8
## 2 MEX             2001 146993.            12.8
## # i 4,097 more rows
```

Joining tables is also error-prone.

- ▶ You want to have a clear mind about which variables from which datasets are kept in your final merged data.
- ▶ Failing to do so can cause difficulty with replication.

Some advice based on personal experience

- ▶ Add suffixes or prefixes indicating data sources
- ▶ Add binary indicators (1/0) indicating from in which dataset is each observation available

Good Habit: Add Availability Indicators

Add binary indicators about data availability in each sources.

```
# The d_gdp_2000_2022 data are from V-Dem
d_gdp_2000_2022_t <- d_gdp_2000_2022 |> mutate(source_vdem = 1)

# *Pretend* that the d_gdppc_1984_2010 data are from the World Bank
d_gdppc_1984_2010_t <- d_gdppc_1984_2010 |> mutate(source_wb = 1)

d_fj_habit <- d_gdp_2000_2022_t |>
  full_join(d_gdppc_1984_2010_t, by = c("country_text_id", "year"))

d_fj_habit |> print(n = 3)
```

```
## # A tibble: 6,789 x 6
##   country_text_id year      gdp source_vdem gdppc source_wb
##   <chr>          <dbl>   <dbl>     <dbl> <dbl>     <dbl>
## 1 MEX            2000 145206.         1  13.7         1
## 2 MEX            2001 146993.         1  13.6         1
## 3 MEX            2002 148549.         1  13.6         1
## # i 6,786 more rows
```

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Good Habit: Add Availability Indicators

What can you do with these binary indicators? We can know the overlaps of multiple sources.

```
d_fj_habit |>
  group_by(source_vdem, source_wb) |>
  count()

## # A tibble: 3 x 3
## # Groups:   source_vdem, source_wb [3]
##   source_vdem source_wb     n
##   <dbl>         <dbl> <int>
## 1         1           1  1951
## 2         1          NA  2148
## 3        NA           1  2690
```

If the overlap looks weird to you, you will know that you need to re-examine the data merging process.

Good Habit: Add Availability Indicators

Question: Why not just check NA in each variables?

Answer: An observation can be missing for two reasons

- ▶ It is in the one of the tables but it does not contain a value.
- ▶ It is not in any of the tables at all.

`join_` make it hard to distinguish between the two scenarios.

Good Habit: Add prefix or suffix to variable names

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- ▶ My previous advice: Give informative names to variable
- ▶ New advice: Add the source of the variables as part of their names if your final dataset is a combination of many different datasets

Good Habit: Add prefix or suffix to variable names

```
d_gdp_2000_2022_rn <- d_gdp_2000_2022 |>
  rename("vdem_gdp" = "gdp")
  # rename_at(vars(-c("country_text_id", "year")), ~str_c("vdem_", .))

d_gdppc_1984_2010_rn <- d_gdppc_1984_2010 |>
  rename("wb_gdppc" = "gdppc")
  # rename_at(vars(-c("country_text_id", "year")), ~str_c("wb_", .))

d_fj_habit_2 <- d_gdp_2000_2022_rn |>
  full_join(d_gdppc_1984_2010_rn, by = c("country_text_id", "year"))

d_fj_habit_2 |> print(n = 3)
```

```
## # A tibble: 6,789 x 4
##   country_text_id year vdem_gdp wb_gdppc
##   <chr>          <dbl>   <dbl>   <dbl>
## 1 MEX            2000  145206.    13.7
## 2 MEX            2001  146993.    13.6
## 3 MEX            2002  148549.    13.6
## # i 6,786 more rows
```