Gravity in R: a short workshop

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This page is dedicated to teach students on running the gravity model in R. We uses dataset from CEPII, specifically BACI and the gravity dataset. We run in R and RStudio IDE, and we rely on fepois() from the "fixest" package when demonstrating PPML. We try to replicate Silva and Tenreyro (2006), an excellent paper for an introduction to the log gravity model and PPML.

For the latest version click here.

Introduction

The gravity model is probably the most popular model in international trade. Many uses them. It is very intuitive, great predictive power, and most importantly, tweakable (Yotov 2022). But the even most important is that UI students love them. If you're doing trade for your thesis, then you probably going to use the gravity model as your backbone.

This guide is my attempt to help you learn gravity model much easier. The most important part is probably the data and the model itself. What is the minimum things you need in the gravity model, how to arrange the database, run them, and interpret them. You must familiarize yourself with the data and its wrangling (80% of your coding) as well as the main gravity specification to date. I encourage students to pay careful attention to Yotov (2022) as it hosts the recent development in the gravity model, a must read if you're planning to utilize gravity model.

I use R here because I use R much more than Stata these days. However, the two language aren't very different. You can do the same thing on both, but you may need to google a bit. It's okay to use google a lot. I did as well even right now. Oh yeah I also informed you guys know R already so I won't go into too much basic stuff.

Next is the preparation you'll need. Make sure you read it carefully and install & download everything in advance!

Preparation

This workshop is conducted with the R statistical software, RStudio IDE, and "fixest" (Bergé 2018; Bergé and McDermott 2024) package, which documatation can be accessed on CRAN. Well, of course you can also explore other packages e.g., gravity (Woelwer et al. 2023) and penppml (Garrucho et al. 2023), or you have ppmlhdfe in Stata (Correia, Guimarães, and Zylkin 2020). Let's stick with fixest for now.

Of course you're going to need tidyverse as well, or specifically dplyr package. You want to procure data beforehand too, and I will use CEPII data. let's discuss one by one.

Software

You'd want to use R and RStudio for this. The main reason I use R is because it's free. Stata is not. I think Stata is faster and a bit easier (R people will kill me if they see this) but not cheap. If you have Stata it's fine too. The command you'd want in Stata is `ppmlhdfe`.

Now onto R. You can procure R and RStudio from Posit's website. Get it here. I wrote the guide to install R and RStudio here, so you better check it out. It's written in Indonesian.

After that, you are going to need to install some packages. Follow my step until I told you to do type this on the console `install.packages(c("tidyverse","WDI","readxl","kableExtra"))`. You are going to do the same but you're going to few different stuff. Specifically, you need to add "fixest", "modelsummary" and "writexl" on the list. That is, you need to type

```
install.packages(c("tidyverse","WDI","readxl","writexl","fixest","modelsummary"))
```

This step requires internet connection, but you'll need to do this only once.

Data

I procure data for this workshop from CEPII. From their website, CEPII is:

> The CEPII is the leading French center for research and expertise on the world economy. It contributes to the policy making process trough its independent in-depth analyses on international trade, migrations, macroeconomics and finance. The CEPII also produces databases and provides a platform for debate among academics, experts, practitioners, decision makers and other private and public stakeholders. Founded in 1978, the CEPII is part of the network coordinated by France Strategy, within the Prime Minister's services.

I use their BACI dataset (Gaulier and Zignago 2010) and gravity dataset (Conte, Cotterlaz, and Mayer 2022). You can get those from this link. BACI is under "international trade" banner while gravity is under "Gravity" banner. Specifically, I downloaded the 2017-2022 version of BACI and for the gravity dataset I downloaded the R version. You can of course download whichever version you like but for the purpose of this workshop maybe its best to stick with the same dataset as I.

You can also download from my drive.

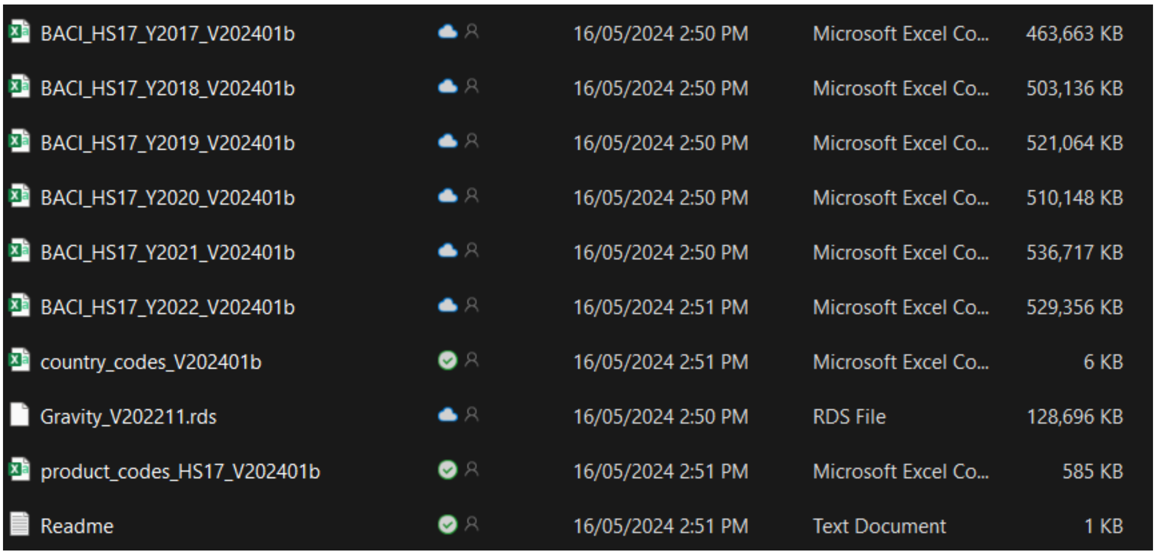
Note that the data here is **extremely large** in size so be mindful. You need hefty internet quota and reasonable speed. Also, you can try opening it with spreadsheet software but unless you have a strong computer, i'd advice against it. Use R instead.

In the CEPII website you can use various other dataset that may be useful for you. At the same time, there are various other source you can utilise for your actual project that's not necessarily from CEPII.

working directory

If you finished downloading data and installing softwares, you then need to set up a working directory. A working directory is basically a folder where you have all the data and your R script (R version of do file). For now what you want is to have a **folder filled with your downloaded data**. Make sure you know the path to this folder. I tend to use easy path for my projects and move it somewhere else when i finished. If you use github or the likes, it'll be even nicer because you can actually wipe out your local repo if you finish.

All in all, you should have a folder with these stuff in it:



BACI_HS17_Y2017_V202401b	16/05/2024 2:50 PM	Microsoft Excel Co...	463,663 KB
BACI_HS17_Y2018_V202401b	16/05/2024 2:50 PM	Microsoft Excel Co...	503,136 KB
BACI_HS17_Y2019_V202401b	16/05/2024 2:50 PM	Microsoft Excel Co...	521,064 KB
BACI_HS17_Y2020_V202401b	16/05/2024 2:50 PM	Microsoft Excel Co...	510,148 KB
BACI_HS17_Y2021_V202401b	16/05/2024 2:50 PM	Microsoft Excel Co...	536,717 KB
BACI_HS17_Y2022_V202401b	16/05/2024 2:51 PM	Microsoft Excel Co...	529,356 KB
country_codes_V202401b	16/05/2024 2:51 PM	Microsoft Excel Co...	6 KB
Gravity_V202211.rds	16/05/2024 2:50 PM	RDS File	128,696 KB
product_codes_HS17_V202401b	16/05/2024 2:51 PM	Microsoft Excel Co...	585 KB
Readme	16/05/2024 2:51 PM	Text Document	1 KB

Notes about the data country_codes, product_codes and Readme are all for reading BACI.

Packages

for this page I use these packages but you may not need all of them

```r
library(tidyverse)
library(writexl)
library(modelsummary)
library(fixest)
```

Simple gravity specification

Theory

The earliest (e.g., naive) gravity model taking directly from Newtonian gravity theory looks something like this:

$$X_{ij} = \tilde{G}\frac{Y_i E_j}{T_{ij}^{\theta}} \tag{0.1}$$

where X_{it} is the value of trade flow from country i to country j, $\tilde{G}$ is the gravitational constant (aka our usual constant), Y_i is the output in country i E_j is the value of expenditure in country j and T_{ij} is the total bilateral trade frictions / trade cost between country i and country j.

There are various other types of gravity equations, but let's start with a relatively simple one. One of my favorite simple gravity specification is a budget version of Silva and Tenreyro (2006) which is taken from Anderson and Wincoop (2003) which looks like this:

$$X_{ij} = \alpha_0 Y_i^{\alpha_1} Y_j^{\alpha_2} D_{ij}^{\alpha_3} e^{\theta_i d_i + \theta_j d_j} \tag{0.2}$$

where α_0 is your $\tilde{G}$, while Y is the output and expenditure which is proxied with GDP. D_{ij} is the distance between the two countries, which can be generalized as a vector of trade cost measures. Typically we use physical distance but also other types of bilateral trade cost. Lastly, the d_i and d_j is country-specific characteristics.

There are various variables used in Silva and Tenreyro (2006). log of exporter's and importer's GDP and GDP per capita. Various "distance" variables is used as well e.g., physical distance and variables like contiguity, common-language dummy, colonial-tie dummy and free trade agreement dummy.

Note that our regression consists only of two indices: exporter i and importer j. We are going to use the gravity data I mentioned earlier, slice the dataset to cover only one year chosen arbitrarily (which is 2019), and run Equation 0.2.

Setting data

first we load all the necessary data:

```
## Readubg data
gravity <- readRDS("Gravity_V202211.rds")
key<-read_csv("country_codes_V202401b.csv")
```

The gravity is the data from CEPII while key is storing some country codes. You can see the first 10 rows of the data and its variable names you call their name. Just type `gravity` or `key` in the console then hit enter. However, if you just want to look at the variable names, you can use `colnames()`

```
colnames(gravity)
```

```
 [1] "year"               "country_id_o"        "country_id_d"
 [4] "iso3_o"             "iso3_d"              "iso3num_o"
 [7] "iso3num_d"          "country_exists_o"    "country_exists_d"
[10] "gmt_offset_2020_o"  "gmt_offset_2020_d"   "distw_harmonic"
[13] "distw_arithmetic"   "distw_harmonic_jh"   "distw_arithmetic_jh"
[16] "dist"               "main_city_source_o"  "main_city_source_d"
[19] "distcap"            "contig"              "diplo_disagreement"
```

```
[22] "scaled_sci_2021"        "comlang_off"            "comlang_ethno"
[25] "comcol"                 "col45"                  "legal_old_o"
[28] "legal_old_d"            "legal_new_o"            "legal_new_d"
[31] "comleg_pretrans"        "comleg_posttrans"       "transition_legalchange"
[34] "comrelig"               "heg_o"                  "heg_d"
[37] "col_dep_ever"           "col_dep"                "col_dep_end_year"
[40] "col_dep_end_conflict"   "empire"                 "sibling_ever"
[43] "sibling"                "sever_year"             "sib_conflict"
[46] "pop_o"                  "pop_d"                  "gdp_o"
[49] "gdp_d"                  "gdpcap_o"               "gdpcap_d"
[52] "pop_source_o"           "pop_source_d"           "gdp_source_o"
[55] "gdp_source_d"           "gdp_ppp_o"              "gdp_ppp_d"
[58] "gdpcap_ppp_o"           "gdpcap_ppp_d"           "pop_pwt_o"
[61] "pop_pwt_d"              "gdp_ppp_pwt_o"          "gdp_ppp_pwt_d"
[64] "gatt_o"                 "gatt_d"                 "wto_o"
[67] "wto_d"                  "eu_o"                   "eu_d"
[70] "fta_wto"                "fta_wto_raw"            "rta_coverage"
[73] "rta_type"               "entry_cost_o"           "entry_cost_d"
[76] "entry_proc_o"           "entry_proc_d"           "entry_time_o"
[79] "entry_time_d"           "entry_tp_o"             "entry_tp_d"
[82] "tradeflow_comtrade_o"   "tradeflow_comtrade_d"   "tradeflow_baci"
[85] "manuf_tradeflow_baci"   "tradeflow_imf_o"        "tradeflow_imf_d"
```

As you can see, the column names are so plenty. Consult to the CEPII website or Conte, Cotterlaz, and Mayer (2022) to learn more. We will only use some of them, so we will filter these data to make it more concise. Specifically, we will (1) remove some countries, (2) remove non-2019, and (3) remove variables we are not using.

For variables, we will keep iso3_o, iso3_d, distw_harmonic, contig, comcol, comlang_off,gdp_o,gdp_d, gdpcap_o, gdpcap_d,fta_wto. Note that o means origin / exporter and d means destination / importer.

```r
## create a country list
ctr<-c("Albania", "Denmark", "Kenya", "Romania", "Algeria", "Djibouti", "Kiribati", "Russi

vrb<-c("iso3num_o","iso3num_d","year","iso3_o", "iso3_d", "distw_harmonic", "contig", "com

## keep 2019
gravity2<-gravity|>filter(year==2019)|> # Keep tahun 2019
  filter(country_id_o!="IDN.1") |> # IDN.1 ini jaman kolonial, kita drop
  filter(country_id_d!="IDN.1") |> # IDEM
  filter(iso3_o!=iso3_d)          # drop obs yang o=d

## Keep countries in the list
key2<-key |> filter(country_name%in%ctr)
gravity2<-gravity2 |> filter(country_id_o %in% key2$country_iso3 &
```

```r
                                 country_id_d %in% key2$country_iso3)
gravity2<-gravity2 |> select(vrb)

## Make a log versin
gravity2<-gravity2 |>
  mutate(ldist=log(distw_harmonic),
         lgdpo=log(gdp_o),
         lgdpd=log(gdp_d),
         lgdpco=log(gdpcap_o),
         lgdpcd=log(gdpcap_d),
         logtrade=log(1+tradeflow_baci))
```

You can see in your environment tab the difference between gravity and gravity2 as well as between key and key2 on the number of observations and variables. Note that we also log non-dummy variables for gravity2 to redo Silva and Tenreyro (2006).

We will focus on the gravity2 as it will be the dataset we will run. You can quickly show summary statistics by typing `summary(gravity2)` on the console tab.

```r
summary(gravity2)
```

```
   iso3num_o       iso3num_d         year          iso3_o         
 Min.   :  8.0   Min.   :  8.0   Min.   :2019   Length:12210      
 1st Qu.:204.0   1st Qu.:204.0   1st Qu.:2019   Class :character  
 Median :400.0   Median :400.0   Median :2019   Mode  :character  
 Mean   :415.5   Mean   :415.5   Mean   :2019                     
 3rd Qu.:616.0   3rd Qu.:616.0   3rd Qu.:2019                     
 Max.   :894.0   Max.   :894.0   Max.   :2019                     

    iso3_d          distw_harmonic       contig            comcol       
 Length:12210       Min.   :  110   Min.   :0.00000   Min.   :0.00000  
 Class :character   1st Qu.: 4546   1st Qu.:0.00000   1st Qu.:0.00000  
 Mode  :character   Median : 7659   Median :0.00000   Median :0.00000  
                    Mean   : 8003   Mean   :0.01769   Mean   :0.09828  
                    3rd Qu.:11062   3rd Qu.:0.00000   3rd Qu.:0.00000  
                    Max.   :19676   Max.   :1.00000   Max.   :1.00000  

  comlang_off          gdp_o                gdp_d               gdpcap_o     
 Min.   :0.0000   Min.   :1.779e+05   Min.   :1.779e+05   Min.   : 0.224  
 1st Qu.:0.0000   1st Qu.:1.419e+07   1st Qu.:1.419e+07   1st Qu.: 1.909  
 Median :0.0000   Median :4.805e+07   Median :4.805e+07   Median : 6.321  
 Mean   :0.1805   Mean   :4.785e+08   Mean   :4.785e+08   Mean   :15.262  
 3rd Qu.:0.0000   3rd Qu.:3.512e+08   3rd Qu.:3.512e+08   3rd Qu.:18.480  
 Max.   :1.0000   Max.   :1.428e+10   Max.   :1.428e+10   Max.   :85.335  
                  NA's   :110         NA's   :110         NA's   :110     
```

```
   gdpcap_d          fta_wto         tradeflow_baci          ldist      
 Min.    : 0.224   Min.    :0.0000   Min.    :         0   Min.    :4.700  
 1st Qu.: 1.909   1st Qu.:0.0000   1st Qu.:       273   1st Qu.:8.422  
 Median : 6.321   Median :0.0000   Median :      6343   Median :8.944  
 Mean    :15.262   Mean    :0.2041   Mean    :   611172   Mean    :8.768  
 3rd Qu.:18.480   3rd Qu.:0.0000   3rd Qu.:     87003   3rd Qu.:9.311  
 Max.    :85.335   Max.    :1.0000   Max.    :149568313   Max.    :9.887  
 NA's    :110                        NA's    :2074                      
     lgdpo           lgdpd           lgdpco           lgdpcd       
 Min.    :12.09   Min.    :12.09   Min.    :-1.4961   Min.    :-1.4961  
 1st Qu.:16.47   1st Qu.:16.47   1st Qu.: 0.6466   1st Qu.: 0.6466  
 Median :17.69   Median :17.69   Median : 1.8438   Median : 1.8438  
 Mean    :17.93   Mean    :17.93   Mean    : 1.8087   Mean    : 1.8087  
 3rd Qu.:19.68   3rd Qu.:19.68   3rd Qu.: 2.9167   3rd Qu.: 2.9167  
 Max.    :23.38   Max.    :23.38   Max.    : 4.4466   Max.    : 4.4466  
 NA's    :110     NA's    :110     NA's    :110       NA's    :110      
    logtrade     
 Min.    : 0.001  
 1st Qu.: 5.613  
 Median : 8.755  
 Mean    : 8.438  
 3rd Qu.:11.374  
 Max.    :18.823  
 NA's    :2074    
```

Regression

Let's do 2 types of regression. First we do a regression using a normal ols, and secondly we do ppml.

```
reg1<-feols(data=gravity2,logtrade~lgdpo+lgdpd+lgdpco+lgdpcd+ldist+contig+
            comcol+comlang_off+fta_wto)
reg2<-feols(data=gravity2,logtrade~lgdpo+lgdpd+lgdpco+lgdpcd+ldist+contig+
            comcol+comlang_off+fta_wto+iso3_o+iso3_d)
reg3<-fepois(data=gravity2,tradeflow_baci~lgdpo+lgdpd+lgdpco+lgdpcd+ldist+
             contig+comcol+comlang_off+fta_wto)
reg4<-fepois(data=gravity2,tradeflow_baci~lgdpo+lgdpd+lgdpco+lgdpcd+ldist+
             contig+comcol+comlang_off+fta_wto+iso3_o+iso3_d)
```

You can call each reg's table with `summary(reg1)`.

You can compare results with Silva and Tenreyro (2006). Note that they don't use fixed effects.

Table 1: Simple regression results

	OLS no dum	OLS w dum	PPML no dum	PPML w dum
(Intercept)	−21.866***	43.403	−15.380***	−118.218***
	(0.414)	(331 632.607)	(0.000)	(0.082)
lgdpo	1.239***	−0.612	0.895***	6.704***
	(0.013)	(13 637.338)	(0.000)	(0.004)
lgdpd	0.947***	−1.135	0.814***	1.349***
	(0.013)	(20 808.385)	(0.000)	(0.003)
lgdpco	0.251***	4.086	−0.041***	−10.947***
	(0.018)	(34 680.508)	(0.000)	(0.009)
lgdpcd	0.066***	7.073	−0.037***	−1.280***
	(0.018)	(52 916.880)	(0.000)	(0.007)
contig	0.899***	0.594**	0.185***	0.334***
	(0.165)	(0.203)	(0.000)	(0.000)
comcol	0.489***	0.317**	0.110***	0.519***
	(0.082)	(0.114)	(0.000)	(0.000)
comlang_off	0.781***	0.778***	0.238***	0.162***
	(0.061)	(0.085)	(0.000)	(0.000)
fta_wto	0.702***	0.559***	0.383***	0.380***
	(0.057)	(0.079)	(0.000)	(0.000)
ldist	−1.215***	−1.466***	−0.606***	−0.711***
	(0.032)	(0.044)	(0.000)	(0.000)
Num.Obs.	9990	9990	9990	9990
R2	0.720	0.611	0.873	0.922
R2 Adj.	0.720	0.602	0.873	0.922
AIC	43 228.2	46 948.9	4 281 748 269.4	2 638 932 248.1
BIC	43 300.3	48 578.2	4 281 748 341.5	2 638 933 863.0
RMSE	2.10	2.48	2 097 486.21	1 585 544.68
Std.Errors	IID	IID	IID	IID

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

TABLE 3.—THE TRADITIONAL GRAVITY EQUATION

Estimator: Dependent Variable:	OLS $\ln(T_{ij})$	OLS $\ln(1 + T_{ij})$	Tobit $\ln(a + T_{ij})$	NLS T_{ij}	PPML $T_{ij} > 0$	PPML T_{ij}
Log exporter's GDP	0.938**	1.128**	1.058**	0.738**	0.721**	0.733**
	(0.012)	(0.011)	(0.012)	(0.038)	(0.027)	(0.027)
Log importer's GDP	0.798**	0.866**	0.847**	0.862**	0.732**	0.741**
	(0.012)	(0.012)	(0.011)	(0.041)	(0.028)	(0.027)
Log exporter's GDP per capita	0.207**	0.277**	0.227**	0.396**	0.154**	0.157**
	(0.017)	(0.018)	(0.015)	(0.116)	(0.053)	(0.053)
Log importer's GDP per capita	0.106**	0.217**	0.178**	−0.033	0.133**	0.135**
	(0.018)	(0.018)	(0.015)	(0.062)	(0.044)	(0.045)
Log distance	−1.166**	−1.151**	−1.160**	−0.924**	−0.776**	−0.784**
	(0.034)	(0.040)	(0.034)	(0.072)	(0.055)	(0.055)
Contiguity dummy	0.314*	−0.241	−0.225	−0.081	0.202	0.193
	(0.127)	(0.201)	(0.152)	(0.100)	(0.105)	(0.104)
Common-language dummy	0.678**	0.742**	0.759**	0.689**	0.752**	0.746**
	(0.067)	(0.067)	(0.060)	(0.085)	(0.134)	(0.135)
Colonial-tie dummy	0.397**	0.392**	0.416**	0.036	0.019	0.024
	(0.070)	(0.070)	(0.063)	(0.125)	(0.150)	(0.150)
Landlocked-exporter dummy	−0.062	0.106*	−0.038	−1.367**	−0.873**	−0.864**
	(0.062)	(0.054)	(0.052)	(0.202)	(0.157)	(0.157)
Landlocked-importer dummy	−0.665**	−0.278**	−0.479**	−0.471**	−0.704**	−0.697**
	(0.060)	(0.055)	(0.051)	(0.184)	(0.141)	(0.141)
Exporter's remoteness	0.467**	0.526**	0.563**	1.188**	0.647**	0.660**
	(0.079)	(0.087)	(0.068)	(0.182)	(0.135)	(0.134)
Importer's remoteness	−0.205*	−0.109	−0.032	1.010**	0.549**	0.561**
	(0.085)	(0.091)	(0.073)	(0.154)	(0.120)	(0.118)
Free-trade agreement dummy	0.491**	1.289**	0.729**	0.443**	0.179*	0.181*
	(0.097)	(0.124)	(0.103)	(0.109)	(0.090)	(0.088)
Openness	−0.170**	0.739**	0.310**	0.928**	−0.139	−0.107
	(0.053)	(0.050)	(0.045)	(0.191)	(0.133)	(0.131)
Observations	9613	18360	18360	18360	9613	18360
RESET test *p*-values	0.000	0.000	0.204	0.000	0.941	0.331

Figure 1: source: Silva and Tenreyro (2006)

By the way, you can save the regression table using `modelsummary()`. don't forget to run `library(modelsummary)` first. You can use xlsx extension, but also docx.

```
regtab<- list(
  "OLS no ctr" = reg1,
  "OLS with ctr"  = reg2,
  "PPML no ctr"=reg3,
  "PPML with ctr"=reg4
)
modelsummary(regtab,output="regtab.xlsx")
```

Product level gravity

Theory

We then proceed to a higher-dimension trade data which you may be interested in. In the field, UI students often interested largely in Indonesian affairs. That is, we are not interested so much in the bilateral flow of all countries, but only on Indonesia. However, we often use more granular dimension than just exporter/importer. Often times we use indices like time, commodities or industries, or even firms (shamelessly inserting my paper here Gupta (2023)).

Now, if you are planning to do these kinds of studies, then you are going to need to tackle higher degree dataset and merging the gravity variables. Most often you can get these variables from World Development Indicators but CEPII is ok for now (note the main problem of CEPII is its timeliness).

The theory isn't so different compared to our previous gravity model. What we want is an additional indices. We are going to estimate something similar as Equation 0.2 but with more indices. We need to care about multilateral resistance (MR) and we can use dummies since we now have more variations from indices like time and HS code.

According to Yotov (2022), we need at least 3 dummies to run a multi-country, multi-time and multi-goods/sectors[1]. We need to have exporter-time dummy, importer-time dummy and country-pair dummy. We need to construct this first. Note that these dummies will likely absorb some of your variables like distance (consistant between pair across time, typically).

So we will do the HS,time varying version of Equation 0.2:

$$X_{ijpt} = \alpha_0 Y_{it}^{\alpha_1} Y_{jt}^{\alpha_2} D_{ijpt}^{\alpha_3} e^{\theta_1 o_{it} + \theta_2 d_{jt} + \theta_3 p_{ij}} \tag{0.3}$$

Setting data

This time we need BACI data. Brace yourself because this dataset is HUGE. We read 5 different years.

```
t2017<-read_csv("BACI_HS17_Y2017_V202401b.csv")
t2018<-read_csv("BACI_HS17_Y2018_V202401b.csv")
t2019<-read_csv("BACI_HS17_Y2019_V202401b.csv")
t2020<-read_csv("BACI_HS17_Y2020_V202401b.csv")
t2021<-read_csv("BACI_HS17_Y2021_V202401b.csv")


## Combining all
trade<-rbind(t2017,t2018,t2019,t2020,t2021)

remove(t2017,t2018,t2019,t2020,t2021)
```

I used `read_csv` from the tydiverse package for reading .csv. rbind is to stack all BACI data (it was separated per year), then I remove the individual BACI to save environment space.

At this point, you can try checking out the two datasets. You can try looking at both data by calling their names. Alternatively, just look at the column names with `colnames()`. Let's try the BACI frist.

[1] unless you have domestic trade data which we typically don't. If you do, then there's borders dummy. More on Yotov (2022).

```r
colnames(trade)
```

```
[1] "t" "i" "j" "k" "v" "q"
```

There are only 6 columns / variables. Here's some information on what thos means

Table 2: Variable explanations

var	meaning
t	year
i	exporter
j	importer
k	product
v	value
q	quantity

Products in Harmonized System 6-digit nomenclature. Values in thousand USD and quantities in metric tons. Exporter and importer is codified using CEPII codes. the codes and it means can be found in the "key" dataset. To have country identities into the BACI dataset, we need to join the two.

To join the two datasets, we need a key variable. A key variable is the variable connecting the two variables. Both needs the same name. So first we need to assign the same name for exporter and importer codes between BACI and gravity.

We know that i in BACI is iso3num_o in gravity, while j in BACI is iso3num_d in gravity. So we rename the one in BACI so both have the same name:

```r
## Change ctr to reduce computation problem
ctr<-c("IDN.2","SGP","VNM","MYS","THA","PHL","USA","CHN","JPN","KOR")
## IDN.2 adalah IDN yang baru yg datanya ada di gravity dataset. coba cek detil
##di gravity dataset

## Rename variable
trade2<-trade|>rename(iso3num_o=i,iso3num_d=j,year=t)

## Kita ulangi gravity2 karena sekarang perlu tahun 2017-2021
gravity2<-gravity|>filter(year>2016 & year<2022)
gravity2<-gravity2 |> filter(country_id_o %in%ctr & country_id_d %in% ctr)
## notice the change
gravity2<-gravity2 |> select(vrb)

## remove negara yang di luar ctr di BACI
trade2<-trade2|>filter(iso3num_o%in%gravity2$iso3num_o &
```

```
                                    iso3num_d%in%gravity2$iso3num_d)

## gabung dengan trade2

gabung<-left_join(gravity2,trade2,by=c("year","iso3num_o","iso3num_d"))
```

Check the results with gabung or `View(gabung)`. The most important thing here is that you have to make sure you understand the changes in variations! Now that we have time and HS (k), a pair of countries can have multiple observations in different year and different goods. tradeflow_baci will be repeated because this is the total trade, while now we focus on v and q as the X_{ijpt}.

Before we go, however, we need to generate our dummies! Remember, we need to make three dummies, o_{it},d_{jt} and p_{ij} (see Equation 0.3). To do that, we do this:

```
gabung <- gabung |>
  mutate(ooo=interaction(iso3num_o,year),
         ddd=interaction(iso3num_d,year),
         ppp=interaction(iso3num_o,iso3num_d))
```

You can check again whether it's made. if you do `tibble(gabung)` you will see that we have created our factor variables. Oh yes, do not forget to log non-factors.

```
gabung<-gabung |>
  mutate(ldist=log(distw_harmonic),
         lgdpo=log(gdp_o),
         lgdpd=log(gdp_d),
         lgdpco=log(gdpcap_o),
         lgdpcd=log(gdpcap_d),
         logtrade=log(1+v)) ## note the difference with before
```

Why don't we show the quick summary statistics?

```
summary(gabung)
```

```
   iso3num_o       iso3num_d          year          iso3_o
 Min.   :156.0   Min.   :156.0   Min.   :2017   Length:675318
 1st Qu.:360.0   1st Qu.:360.0   1st Qu.:2018   Class :character
 Median :410.0   Median :410.0   Median :2019   Mode  :character
 Mean   :455.6   Mean   :485.8   Mean   :2019
 3rd Qu.:702.0   3rd Qu.:702.0   3rd Qu.:2020
 Max.   :840.0   Max.   :840.0   Max.   :2021

    iso3_d          distw_harmonic      contig      comcol    comlang_off
```

```
 Length:675318      Min.   :   10   Min.   :0   Min.   :0   Min.   :0.00000
 Class :character   1st Qu.: 1983   1st Qu.:0   1st Qu.:0   1st Qu.:0.00000
 Mode  :character   Median : 2386   Median :0   Median :0   Median :0.00000
                    Mean   : 2851   Mean   :0   Mean   :0   Mean   :0.08458
                    3rd Qu.: 4138   3rd Qu.:0   3rd Qu.:0   3rd Qu.:0.00000
                    Max.   :15486   Max.   :0   Max.   :0   Max.   :1.00000

     gdp_o               gdp_d              gdpcap_o          gdpcap_d
 Min.   :3.285e+08   Min.   :3.285e+08   Min.   : 3.123   Min.   : 3.123
 1st Qu.:4.997e+08   1st Qu.:3.970e+08   1st Qu.: 7.233   1st Qu.: 4.135
 Median :1.624e+09   Median :1.059e+09   Median :12.556   Median :10.144
 Mean   :4.282e+09   Mean   :3.352e+09   Mean   :24.902   Mean   :23.307
 3rd Qu.:5.040e+09   3rd Qu.:4.937e+09   3rd Qu.:39.285   3rd Qu.:39.285
 Max.   :2.300e+10   Max.   :2.300e+10   Max.   :72.794   Max.   :72.794

    fta_wto       tradeflow_baci           k                   v
 Min.   :0.0000   Min.   :   592555   Length:675318      Min.   :       0
 1st Qu.:1.0000   1st Qu.:  9006116   Class :character   1st Qu.:       9
 Median :1.0000   Median : 18272115   Mode  :character   Median :     124
 Mean   :0.8758   Mean   : 34989027                      Mean   :    9266
 3rd Qu.:1.0000   3rd Qu.: 42822895                      3rd Qu.:    1443
 Max.   :1.0000   Max.   :500928196                      Max.   :42892726
                  NA's   :139250                         NA's   :112
       q                  ooo                ddd                ppp
 Min.   :       0   156.2019: 26874   702.2019: 21217   156.410: 23391
 1st Qu.:       0   156.2021: 26692   702.2018: 21012   156.764: 22295
 Median :      11   156.2020: 26599   360.2020: 21004   156.392: 22228
 Mean   :    6199   156.2018: 26224   360.2019: 20959   156.360: 21896
 3rd Qu.:     166   156.2017: 25350   702.2021: 20862   156.702: 21840
 Max.   :88344459   392.2019: 24725   702.2020: 20823   392.764: 21516
 NA's   :9882       (Other) :518854   (Other) :549441   (Other):542152
     ldist           lgdpo           lgdpd           lgdpco
 Min.   :2.303   Min.   :19.61   Min.   :19.61   Min.   :1.139
 1st Qu.:7.592   1st Qu.:20.03   1st Qu.:19.80   1st Qu.:1.979
 Median :7.777   Median :21.21   Median :20.78   Median :2.530
 Mean   :7.778   Mean   :21.32   Mean   :21.03   Mean   :2.760
 3rd Qu.:8.328   3rd Qu.:22.34   3rd Qu.:22.32   3rd Qu.:3.671
 Max.   :9.648   Max.   :23.86   Max.   :23.86   Max.   :4.288

     lgdpcd         logtrade
 Min.   :1.139   Min.   : 0.001
 1st Qu.:1.419   1st Qu.: 2.282
 Median :2.317   Median : 4.828
 Mean   :2.607   Mean   : 4.893
 3rd Qu.:3.671   3rd Qu.: 7.275
 Max.   :4.288   Max.   :17.574
```

```
                NA's   :112
```

Regression

```
ger1<-feols(data=gabung,logtrade~lgdpo+lgdpd+lgdpco+lgdpcd+contig+comcol+
            comlang_off+fta_wto+ldist)
ger2<-feols(data=gabung,logtrade~lgdpo+lgdpd+lgdpco+lgdpcd+contig+comcol+
            comlang_off+fta_wto+ldist+ooo+ddd+ppp)
ger3<-fepois(data=gabung,v~lgdpo+lgdpd+lgdpco+lgdpcd+contig+comcol+
             comlang_off+fta_wto+ldist)
ger4<-fepois(data=gabung,v~lgdpo+lgdpd+lgdpco+lgdpcd+contig+comcol+
             comlang_off+fta_wto+ldist+ooo+ddd+ppp)
```

As you can see, the difference is apparent when we use HS-6-digit instead of total trade. This is of course the case since now we have wild, uncontrolled variability in the goods characteristics. Indeed, the gravity equation is much better suited predicting total trade where country and year characteristics dominates and industry/goods heterogeneity is absorbed by the total trade. Remember, I use only small number of countries with tons of HS 6 digit[2]. Moreover, PPML sometimes act funny where zeroes are abundant combined with many dummies. Convergence sometimes unachieved / converge to a very strange parameters.

UI students typically only interested in Indonesia, so country pair dummy and indonesia-time dummy often not needed. Of course then you can add dummies like sector dummy or HS Chapter dummy.

Closing

OKay now you are ready to run regression yourself. Try to replicate what I do here and you prolly finished 50% of your thesis. You then can work to update this with your own hypothesis, adding more variable and more concentrated.

Running this on Stata is also excellent. I must confess that R is also speedy (these guys making the package is extremely good), but Stata is a bit more intuitive and compute you with important stats as well such as pseudo-R. Nevertheless, now you should be able to do both!

As you are a student now, I encourage you to explore as much as you can because this is the moment. Once you're a proper adult, you must think more mundane stuff so please value your freedom at this point and explore as much as you can! Go out there make mistakes while you can!

[2] I added JPN, KOR, CHN and USA in this version. Previously it was only ASEAN6 and results were pretty funny since within-ASEAN trade isn't so large.

Table 3: Simple regression results

	OLS no dum	OLS with dum	PPML no dum	PPML with dum
(Intercept)	−18.436***	0.129	−12.672***	−76.370***
	(0.112)	(1274.150)	(0.001)	(5.664)
lgdpo	0.860***	0.191	0.529***	−1.870***
	(0.003)	(107.572)	(0.000)	(0.211)
lgdpd	0.373***	1.667	0.580***	4.613***
	(0.003)	(1.259)	(0.000)	(0.007)
lgdpco	−0.001	−16.332	0.032***	3.880***
	(0.004)	(1733.225)	(0.000)	(0.344)
lgdpcd	−0.062***	−0.044	0.062***	0.414***
	(0.004)	(0.081)	(0.000)	(0.000)
comlang_off	0.228***	0.678***	0.360***	0.549***
	(0.013)	(0.115)	(0.000)	(0.001)
fta_wto	−0.081***	−1.126	0.347***	−7.578***
	(0.015)	(1.448)	(0.000)	(0.007)
ldist	−0.337***	0.062	−0.343***	2.587***
	(0.006)	(0.513)	(0.000)	(0.003)
Num.Obs.	675 206	675 206	675 206	675 206
R2	0.146	0.165	0.121	0.130
R2 Adj.	0.146	0.165	0.121	0.130
AIC	3 353 993.3	3 338 724.4	36 199 829 363.4	35 817 601 698.7
BIC	3 354 084.7	3 339 821.0	36 199 829 454.8	35 817 602 829.6
RMSE	2.90	2.87	138 393.96	138 371.77
Std.Errors	IID	IID	IID	IID

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

I cannot emphasize enough references in Yotov (2022). Whatever you want to do, a paper prolly covered it already. Learn from them and look for an insight to add. Work with your spv and you'll be fine.

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