

Description of Data Analysis

Yue

2023/3/8

Description of Data Analysis

We are currently at the stage of **Visualization of Results and Covariance Analysis**. The following content introduces the data we have now and the expected presentation ways. This is an important step before we reach the final discussion. We expect to reveal some interesting story lines from the data visualization and covariance analysis.

Data Description

After data collection, cleaning and calculation of nitrogen footprint, we have obtained four main datasets: 1. **FPcontinent** that shows the total nitrogen footprints (sum of Leaching and Volatilization) of continents and world total from 1986 to 2020.

##	V1	X	continent	Leaching	Volatilization	TN	Year	population
## 1:	1	1	EAC	4209881.372	1790310.5047	6000191.877	1986	1077770523
## 2:	2	2	EAP	1633169.142	723955.3760	2357124.518	1986	641551109
## 3:	3	3	ECA	4501578.847	2094123.5491	6595702.396	1986	821249074
## 4:	4	4	LAC	1521778.209	737165.9451	2258944.154	1986	408924912
## 5:	5	5	MENA	660659.659	281436.1758	942095.835	1986	226497142
## 6:	6	6	North America	2004269.672	862659.4541	2866929.126	1986	263628854
## 7:	7	7	RoW	7523.183	3730.6939	11253.877	1986	49297006
## 8:	8	8	SA	1347.694	600.8788	1948.573	1986	888980
## 9:	9	9	South Asia	1882615.262	823126.3814	2705741.644	1986	1041669850
## 10:	10	10	SSA	301390.230	141592.4886	442982.719	1986	391916817
##			Leachingpc	Volatilpc	TNpc			
## 1:	0.0039061018	0.0016611240	0.0055672258					
## 2:	0.0025456571	0.0011284454	0.0036741025					
## 3:	0.0054813807	0.0025499250	0.0080313057					
## 4:	0.0037214123	0.0018026927	0.0055241050					
## 5:	0.0029168565	0.0012425595	0.0041594160					
## 6:	0.0076026188	0.0032722498	0.0108748685					
## 7:	0.0001526093	0.0000756779	0.0002282872					
## 8:	0.0015160008	0.0006759193	0.0021919201					
## 9:	0.0018073051	0.0007901989	0.0025975040					
## 10:	0.0007690158	0.0003612820	0.0011302978					

where **Leaching** is nitrogen emissions to the water bodies (ammonia), **Volatilization** is nitrogen emissions to the air (nitrate, NOx, nitrous oxides), **TN** is the total nitrogen missions. The continent abbreviations are: East Asia and Pacific (EAC), Europe and Central Asia (ECA), Latin America & the Caribbean (LAC), Middle East and North Africa (MENA), North America, South Asia, Sub-Saharan Africa (SSA), RoW (rest of world).

2. FPcountry that shows nitrogen emission summary of some selected countries of interest, which are China(CHN),USA,Brazil(BRA),Australia(AUS),India(IND),Germany(DEU),South Africa(ZAF),United Arab Emirate(ARE).

##	V1	X	area_code	iso3c	Leaching	Volatilization	TN	Year	population
## 1:	1	1	10	AUS	59687.156	27355.002	87042.158	1986	16012299
## 2:	2	2	21	BRA	433820.271	236491.070	670311.340	1986	139643355
## 3:	3	3	41	CHN	4209881.372	1790310.505	6000191.877	1986	1077770523
## 4:	4	4	79	DEU	746090.121	353553.038	1099643.160	1986	77803357
## 5:	5	5	100	IND	1484629.869	647602.896	2132232.764	1986	797878993
## 6:	6	6	202	ZAF	87501.294	35495.143	122996.436	1986	34877834
## 7:	7	7	225	ARE	6175.974	2853.859	9029.833	1986	1468697
## 8:	8	8	231	USA	1798839.545	775310.261	2574149.805	1986	237512783

##	Leachingpc	Volatilpc	TNpc
## 1:	59687.156	27355.002	87042.158
## 2:	433820.271	236491.070	670311.340
## 3:	4209881.372	1790310.505	6000191.877
## 4:	746090.121	353553.038	1099643.160
## 5:	1484629.869	647602.896	2132232.764
## 6:	87501.294	35495.143	122996.436
## 7:	6175.974	2853.859	9029.833
## 8:	1798839.545	775310.261	2574149.805

3. Nexchange that shows the nitrogen net importing countries (which means they import foreign agri-food products and cause more nitrogen emissions abroad than the domestic nitrogen pollution they bear from exporting) and net exporting countries (vice versa).

##	V1	X	area_code	area	TNflow	Leaching
## 1:	1	1	110	Japan	433953.84	123319.62
## 2:	2	2	228	USSR	304762.78	88213.06
## 3:	3	3	106	Italy	256342.51	75111.71
## 4:	4	4	15	Belgium-Luxembourg	105102.90	31194.43
## 5:	5	5	236	Venezuela (Bolivarian Republic of)	104607.09	29384.07
## 6:	6	6	170	Peru	90409.87	25466.28
## 7:	7	7	59	Egypt	72696.43	21362.76
## 8:	8	8	194	Saudi Arabia	61858.73	18567.49
## 9:	9	9	203	Spain	61023.02	18870.62
## 10:	10	10	79	Germany	60137.88	NA
## 11:	11	11	9	Argentina	-75604.51	-27029.05
## 12:	12	12	216	Thailand	-76238.90	NA
## 13:	13	13	10	Australia	-87638.98	-25693.17
## 14:	14	14	999	RoW	-99552.04	-31338.62
## 15:	15	15	33	Canada	-113827.27	-30705.18
## 16:	16	16	54	Denmark	-132933.95	-39978.60
## 17:	17	17	97	Hungary	-136881.48	-38987.48
## 18:	18	18	68	France	-278533.55	-81872.90
## 19:	19	19	41	China, mainland	-301987.72	-83415.69
## 20:	20	20	231	United States of America	-888057.79	-244593.04

##	Volatile	Year	population	pcNflow
## 1:	310634.22	1986	121710305	0.0035654650
## 2:	216549.73	1986	279839010	0.0010890647
## 3:	181230.79	1986	56639054	0.0045258967
## 4:	73908.48	1986	10255985	0.0102479581

```

## 5: 75223.01 1986 17860872 0.0058567738
## 6: 64943.59 1986 20208437 0.0044738676
## 7: 51333.67 1986 51424313 0.0014136587
## 8: 43291.23 1986 13483349 0.0045877865
## 9: 42152.41 1986 38590808 0.0015812839
## 10: 43874.77 1986 77803357 0.0007729471
## 11: -48575.47 1986 30748326 -0.0024588172
## 12: -52859.13 1986 51542094 -0.0014791580
## 13: -61945.81 1986 16012299 -0.0054732289
## 14: -68213.42 1986 49297006 -0.0020194338
## 15: -83122.09 1986 26116071 -0.0043585143
## 16: -92955.35 1986 5119369 -0.0259668623
## 17: -97894.00 1986 10505772 -0.0130291693
## 18: -196660.64 1986 55371639 -0.0050302565
## 19: -218572.02 1986 1077770523 -0.0002801967
## 20: -643464.75 1986 237512783 -0.0037389894

```

where positive TNflow corresponds to net nitrogen importing countries, and negative TNflow indicates net nitrogen exporting countries. The data set only includes 10 top net importing and 10 top net exporting countries for each year.

4. food_emission that shows the total nitrogen embedded in the food trading.

```

##      source_iso final_item      TN Year iso3c
## 1      AFG      Cereals 1.631697e-24 1986  CHN
## 2      ALB      Cereals 2.319641e+01 1986  CHN
## 3      DZA      Cereals 2.491895e-25 1986  CHN
## 4      ARG      Cereals 1.047214e+03 1986  CHN
## 5      AUS      Cereals 9.871809e+03 1986  CHN
## 6      AUT      Cereals 3.262906e+01 1986  CHN
## 7      BGD      Cereals 1.867387e-25 1986  CHN
## 8      BOL      Cereals 2.264044e-02 1986  CHN
## 9      BWA      Cereals 8.797258e-03 1986  CHN
## 10     BRA      Cereals 9.044533e-01 1986  CHN

```

where source_iso indicates the food producing country, final_item indicates the food item, final is the final food consumption country.

We also collect nitrogen utilization efficiency (NUE) from FAO and economic data including gdppe (gdp per capita), p10 (income share of top10 wealthy people) and commodity prices (energy, food, fertilizers, oil etc.). The following graph is a glimpse of these economic data (world_eco, country_eco).

```

##      V1 Year Energy  Food Fertilizers Metals_Minerals Deflator_MUV oil_price
## 1: 1 1986 31.828 62.029      39.598          41.295      68.651      NA
## 2: 2 1987 32.591 60.417      38.789          47.949      75.230      NA
## 3: 3 1988 26.452 72.313      44.382          70.440      80.113      NA
## 4: 4 1989 30.971 73.706      42.478          64.759      79.633     17.31
## 5: 5 1990 37.436 66.143      42.062          54.840      82.672     22.26
## 6: 6 1991 32.971 66.044      47.431          47.090      81.912     18.62
## 7: 7 1992 31.415 64.563      42.539          44.724      83.443     18.44
## 8: 8 1993 27.743 62.698      35.282          37.237      86.323     16.33
## 9: 9 1994 26.664 69.434      39.227          46.060      83.730     15.53
## 10: 10 1995 25.977 68.533      42.094          51.090      91.920     16.86

```

```
##      gdppc    p10      pop
## 1: 12547.7 0.5256 4936097368
## 2: 12662.4 0.5301 5024386163
## 3: 12899.6 0.5353 5113492328
## 4: 13052.2 0.5382 5202698711
## 5: 13011.5 0.5425 5293517142
## 6: 12836.8 0.5403 5382656065
## 7: 12744.7 0.5495 5470276947
## 8: 12768.9 0.5527 5556722537
## 9: 12863.0 0.5590 5642128764
## 10: 13036.8 0.5621 5726801833
```

Expected Plots and Analysis

The initial research questions related to these data sets are as follows.

1. Related to FPcontinent, FPcountry, world_eco,country_eco,NUE:
 - How does the world and continent nitrogen footprint TN **evolve** in 35 years?
 - The **comparison** of nitrogen emissions per capita between selected countries and the world average.
 - How does world nitrogen footprint **covariate** with NUE and economic variables such as **gdppc** and **p10**.

Please refer to Fig 1 and Fig 2 to see expected results.

2. Related to Nexchange
 - What is the **general relationship** between net exporting countries and net importing countries? Is there developing-developed or emerging-developed relationship?
 - How does the **relationship change** over the 35 years?

Please refer to Fig 3 to see expected result.

3. Related to food_emission
 - How does nitrogen emissions **vary** among food groups?
 - The **relationship** between food producing countries and food consuming countries.
 - How does nitrogen embedded in food consumption **evolve** over 35 year?
 - Is there **covariance** between nitrogen emissions of certain food groups?

Please refer to Fig 4 to see expected result.

Plan and Schedule

The graphs are important for digging into the interesting pattern of global nitrogen emissions over the 35 years. Initial visualization would help us understand the research questions so we could ask more detailed, specific and interesting questions.

It is expected to finish the initial plotting in one week (before 2023-3-15).

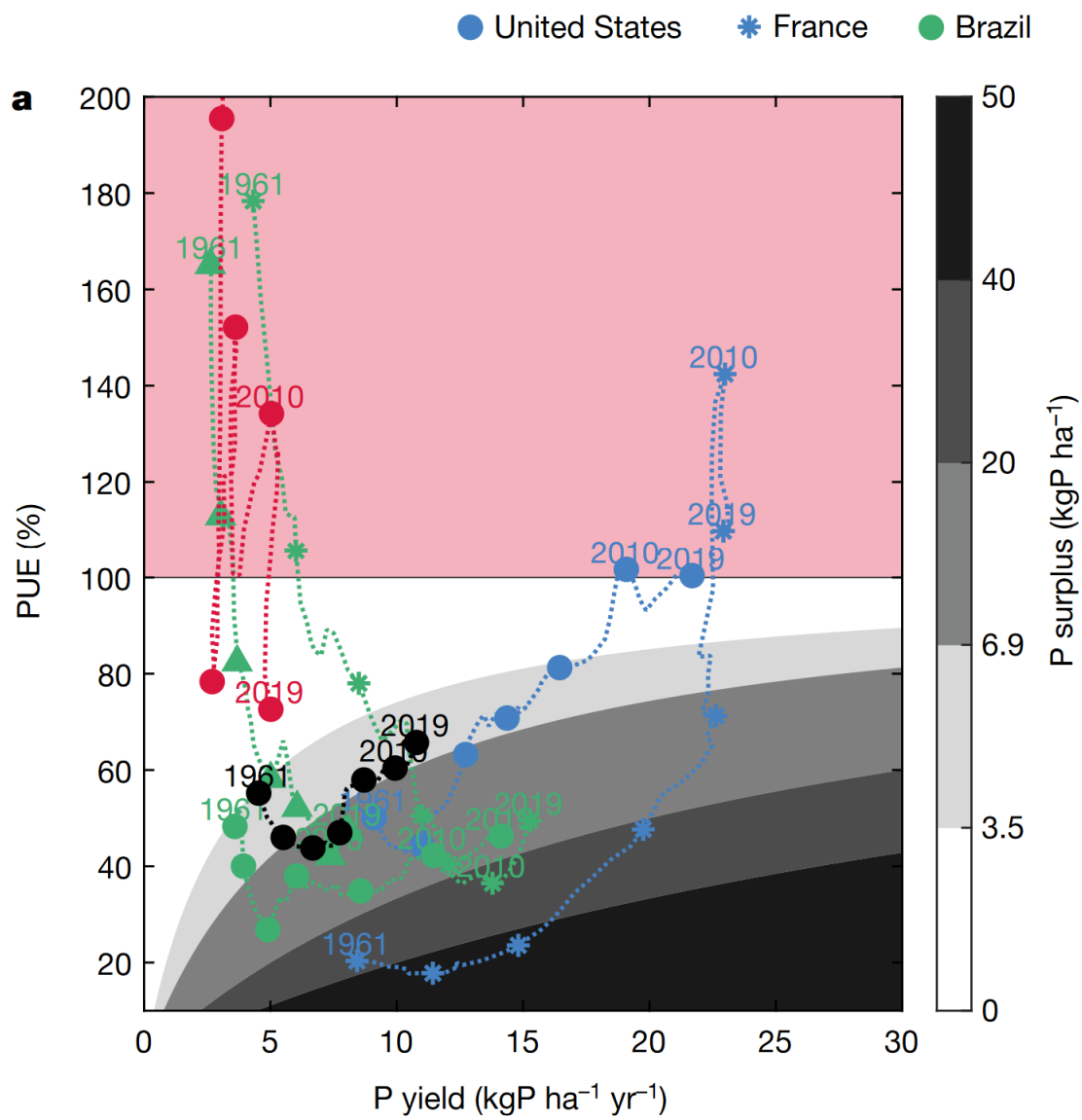


Figure 1: Evolution of PUE

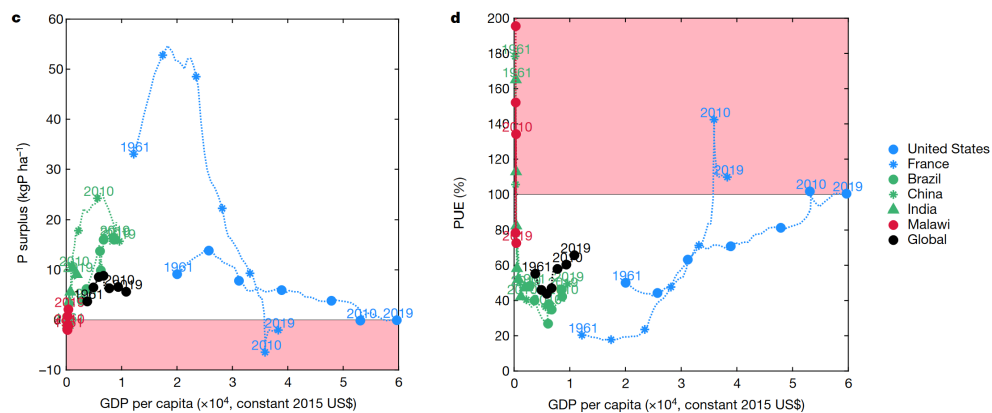


Figure 2: Covariance between PUE and GDP

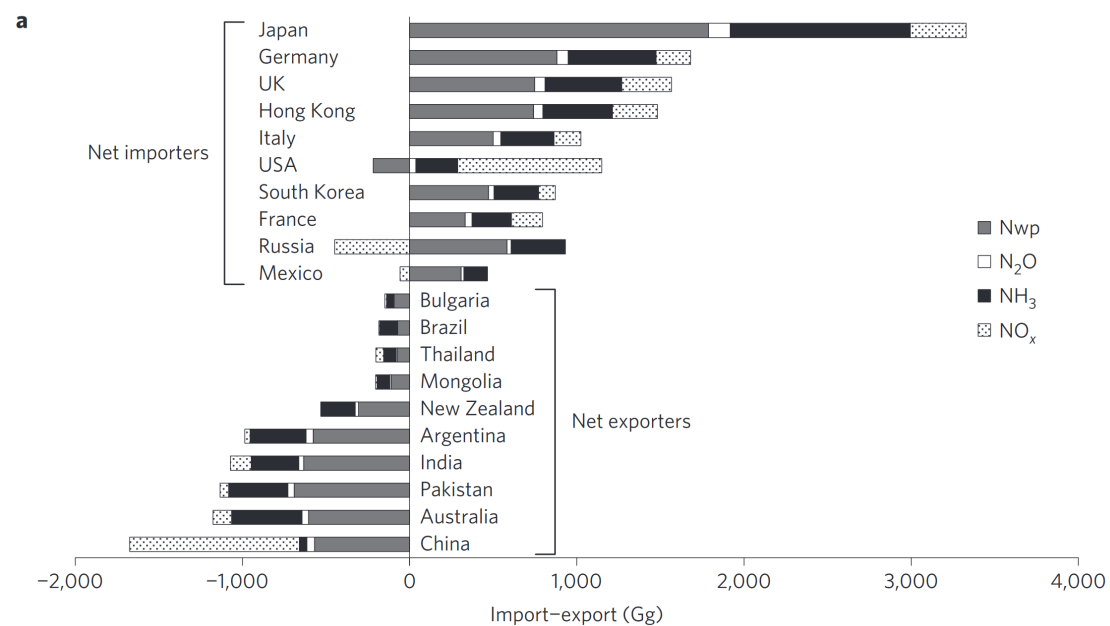


Figure 3: Nitrogen exchange country pairs

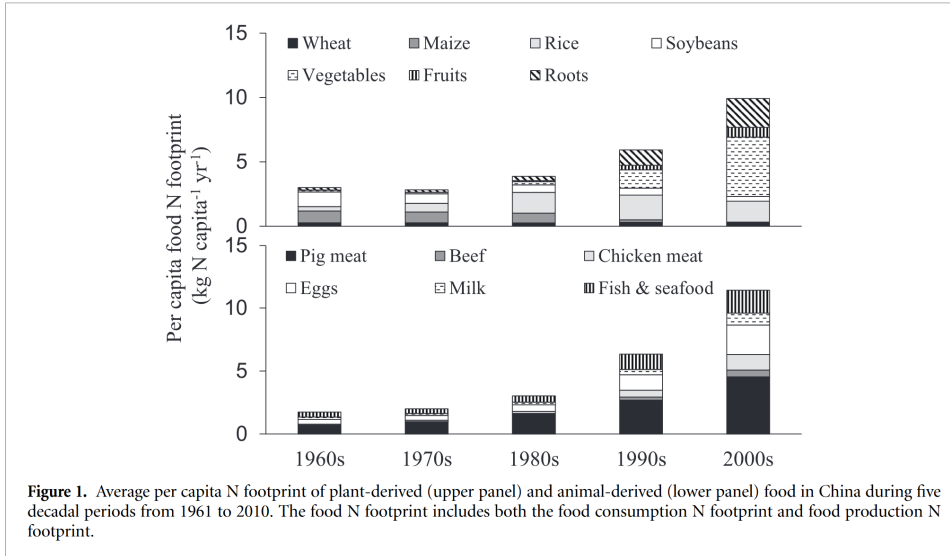


Figure 4: Nitrogen emissions embedded in food

Resources

- Github link: <https://github.com/xiaoyueyoyo/Nitrogen-extended-FABIO>
- Code: 5_Analysis.R
- Important References:
 1. Guo, M. et al. (2017) 'How China's nitrogen footprint of food has changed from 1961 to 2010', *Environmental Research Letters*, 12(10), p. 104006. Available at: <https://doi.org/10.1088/1748-9326/aa81d9>.
 2. Oita, A. et al. (2016) 'Substantial nitrogen pollution embedded in international trade', *Nature Geoscience*, 9(2), pp. 111–115. Available at: <https://doi.org/10.1038/ngeo2635>.
 3. Zou, T., Zhang, X. and Davidson, E.A. (2022) 'Global trends of cropland phosphorus use and sustainability challenges', *Nature*, 611(7934), pp. 81–87. Available at: <https://doi.org/10.1038/s41586-022-05220-z>.