Biodiversity Index and Biodiversity trend for the 35 main world economies

Suggested citation:

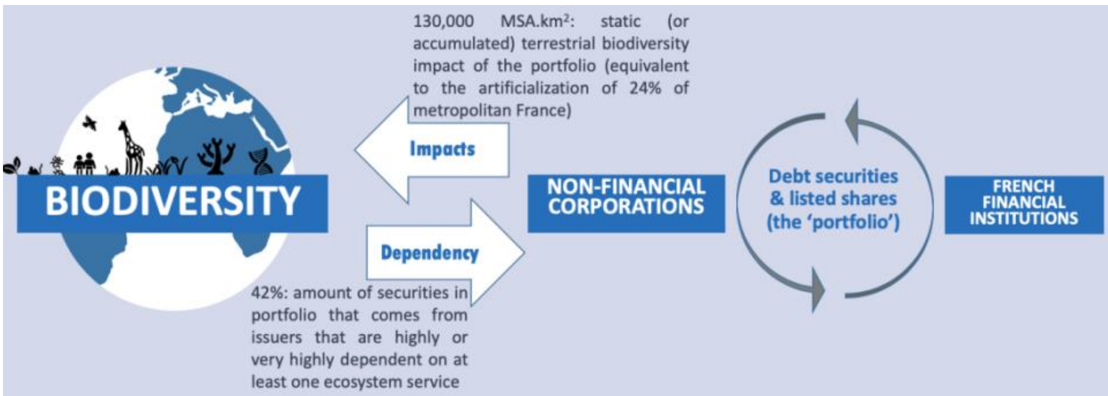
Huang, Yujun and Créti, Anna and Jiang, Binghan and Sanin, Maria Eugenia, Biodiversity Risk, Firm Performance, and Market Mispricing (February 1, 2024). Available at SSRN: https://ssrn.com/abstract=4765039 or http://dx.doi.org/10.2139/ssrn.4765039

General Context

According to the European Central Bank's Guide on climate-related and environmental risks, it is essential to assess and measure physical climate risks such as chronic environmental changes, as these pose long-term threats to financial stability and economic performance across sectors in Europe (ECB, 2020). Biodiversity loss is considered a type of physical climate risk because it directly affects ecosystems' resilience to climate change impacts, such as floods, droughts, and other extreme weather events. As noted by the European Environment Agency, "the loss of biodiversity can exacerbate climate-related risks, as ecosystems with reduced biodiversity are less able to provide essential services like carbon sequestration, water filtration, and protection against natural disasters" (EEA, 2020). In this context, several studies suggest that biodiversity loss may impact economic activity directly and indirectly (Cardinale et al., 2012).

French case

The French Biodiversity Strategy 2030 details the dependency of economic activity on biodiversity as well as the impacts that economic activity has on biodiversity, as we can observe in the following figure.



Source: Svartzman et al. (2021), Banque de France

Objective of the database: measure chronical biodiversity loss as a climate physical risk

Our database measures **biodiversity loss as one type of climate physical risk**. According to the Task Force on Climate-related Financial Disclosures (2017), climate physical risk refers to the potential loss to assets, people and economies caused by physical hazards resulting from climate change. These risks can be acute, such as extreme weather events (e.g., hurricanes, floods, wildfires), or chronic, like rising sea levels, increasing temperatures, long-term shifts in climate patterns and loss in ecosystems. Biodiversity loss is indeed a type of chronic physical risk.

Physical risks can impact infrastructure, supply chains, natural resources, and consequently represent economic losses.[1] According to NGFS (2020), physical risks provoke negative impacts at the individual level (e.g., property damage, business disruption, loss of income) and on the aggregated level (e.g., capital depreciation, productivity changes, labor market frictions), and those effects generate financial risks through the interaction of economy and financial system feedback.

Metadata

Herein we describe how our data succeeds in measuring biodiversity loss at the country level for 35 countries.

Details on the construction of the Biodiversity Index

To build our index we use data provided by the "Ecological Footprint Initiative" for the period 1961-2020. The source data can be found in Dworatzek et al. (2024) while details on the database construction and measures can be found in Lin et al. (2018) and to a certain extent in Borucke et al. (2013).

From such data we extract two measures for the 35 main economies in the world:

a. The “bio-footprint” index that traces the footprint (or degradation) of biodiversity at the national level. This index is an extraction from Dworatzek et al. (2024) data of what Lin et al. (2018) call “Ecological Footprint” (EF) and define as follows

$$EF = (Pn/Yw) * EQF$$

1 This is different from transition risk that refers to the financial risks associated with the process of adjusting to a lower-carbon economy. These risks arise from changes in policies, regulations, technologies, and market preferences as industries and governments transition away from fossil fuels. Transition risks can provoke the decrease for demand for carbon-intensive products, or provoke losses by making certain assets obsolete (e.g., stranded assets). See also TCFD, 2017 and NFRD, 2014.

where:
- Pn is the production (or harvest) in tons per year in country "n" in one land-use category as described hereafter;
- Yw is the world average yield for this land-use category in tons per hectare, per year;
- EQF an equivalence factor that we do not detail herein since we do not need it but that is explained in Lin et al. (2018).

The land-use categories included are the following:
1. Fishing Grounds: Area of marine and inland waters used to produce the fish, invertebrates, and aquatic plants that were captured or cultured by humans
2. Built-up land: Area of land occupied by human-built infrastructure, including housing and other buildings, roads and paved areas, and urban greenspace
3. Cropland: Area of cropland used to grow food and fiber crops consumed by humans, and for crops that humans fed to animals and cultured fish
4. Grazing land: Area of grassland needed to feed livestock beyond the feed supplied by crops
5. Forest Products: Area of forests harvested for timber products and pulpwood
6. Forest carbon up-take: Area of forests needed to sequester anthropogenic carbon emissions from the combustion of fuels including for electricity generation and for the production and transportation of globally traded goods, minus the proportion of anthropogenic emissions sequestered in the same year by the world's oceans

The bio-footprint index we present in our database is then divided by population per country so that we obtain a per-capita value.

b. The "bio-capacity" index that traces the biodiversity capacity at the national level. It is an extraction of the "Biocapacity" measure in Dworatzek et al. (2024) data that is defined in Lin et al. (2018) as follows:

$$\text{Biocapacity} = An * Yn/Yw * EQF$$

where:
- An is the area in country "n" for this land-use category:
- Yn is the national average yield for this land-use category in tons per hectare and year;
and the rest are the same as before.
We then also divide by the country´s population to express it in per-capita terms.

Using the previous two measures, we construct our Biodiversity index as a ratio between bio-capacity and bio-footprint. The resulting measure can then be expressed as follows and traces the total (and potential) yield as compared to the total output:

$$\textbf{Biodiversity index} = (An * Yn)/ Pn.$$

We can interpret the values of this ratio as follows: the value of the index superior to 1 means that global biological resilience outweighs the destruction of biodiversity by production activities, and vice versa. Here, we closely follow Dasgupta (2021), as the author affirms: "ensure that our demands on nature do not exceed its supply and that we increase nature's supply relative to its current level."

Details on the construction of the biodiversity trend

We use simple econometrics to estimate the biodiversity trend using the following equation:

$$\text{Biodiversity Index}_{c,t} = \beta_{0,c} + \beta_{1,c}t + \beta_{2,c}\text{Biodiversity Index}_{c,t-1} + \epsilon_{c,t}$$

We estimate it both in a 30-year rolling window and from the exact beginning for each country between 1991 and 2020.

$\beta_{1,c}$ is then the biodiversity trend estimation and conceptually represents unexpected shock in biodiversity loss over time given the hypothesis that the biodiversity index is self-correlated from year t-1 to year t.

The coefficient can be interpreted as follows: if the estimated trend in 30-year rolling window is negative for country n, it means the biodiversity in such country degrades more quickly than expected, and verse-versa if its positive. We also do it from the exact beginning (year 1961) to check the robustness of our estimation.

References

- Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., ... & Naeem, S. (2012). Biodiversity loss and its impact on humanity. Nature, 486(7401), 59-67.
- Borucke, M., Moore, D., Cranston, G., Gracey, K., Iha, K., Larson, J., Lazarus, E., Morales, J.C., Wackernagel, M. and Galli, A., 2013. Accounting for demand and supply of the biosphere's regenerative capacity: The National Footprint Accounts' underlying methodology and framework. Ecological indicators, 24, pp.518-533. doi:10.1016/j.ecolind.2012.08.005
- Dasgupta, P. (2021). *The economics of biodiversity: The dasgupta review.* United Kingdom Her Majesty's Treasury: London, UK
- Dworatzek, P., Miller, E., Lo, Kiona., Howarth, E., & Kazubowski-Houston, S. 2024. National Ecological Footprint and Biocapacity Accounts, 2024 Edition. (Version 1.0). [Data set and metadata]. Produced for Footprint Data Foundation by York University Ecological Footprint Initiative in partnership with Global Footprint Network. https://footprint.info.yorku.ca/data/
- ECB (2020). European Central Bank's Guide on climate-related and environmental risks https://www.bankingsupervision.europa.eu/legalframework/publiccons/pdf/climate-related_risks/ssm.202005_draft_guide_on_climate-related_and_environmental_risks.en.pdf

- EEA (2020). European Environment Agency, https://www.eea.europa.eu/soer/2020
- Lin, D., Hanscom, L., Murthy, A., Galli, A., Evans, M., Neill, E., Mancini, M.S., Martindill, J., Medouar, F.Z., Huang, S. and Wackernagel, M., 2018. Ecological footprint accounting for countries: updates and results of the national footprint accounts, 2012–2018. Resources, 7(3), p.58. doi:10.3390/resources7030058
- TCFD (2017). Final report: Recommendations of the task force on climate-related financial disclosures. Task Force on Climate-related Financial Disclosures. https://www.fsb-tcfd.org/publications/final-recommendations-report/
- NFRD. (2014). Non-financial reporting directive. https://www.greenfinanceplatform.org/policies-and-regulations/non-financial-reporting-directive-nfrd-directive-201495eu-and-proposal#:~:text=The%20European%20Union%20(EU)%20Directive,of%20employees%2C%20respect%20for%20human
- NGFS. (2020). Network for greening the financial system technical document. https://www.ngfs.net/sites/default/files/medias/documents/ngfs_annual_report_2020.pdf
- Svartzman, R., Espagne, E., Julien, G., Paul, H. L., Mathilde, S., Allen, T., ... & Vallier, A. (2021). A'Silent Spring'for the Financial System? Exploring Biodiversity-Related Financial Risks in France.