



CLIMATE RISK

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A Decade After Paris: Accelerating Progress Towards Net-Zero

ECGI Responsible Summit

Berlin

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SCIENCE

- Science knows that if the energy coming to the earth is greater than the energy escaping from the earth, its temperature will rise. The layer of greenhouse gasses around the earth is now trapping heat that in the last million years would have been emitted back into space.
- The rapid increase in CO₂ and other greenhouse gasses is due to the rate at which we humans burn fossil fuels.
- These fuels were created over countless millennia by plants which converted the sun's energy into organic molecules which have been stored in the earth and sea. By burning these fuels, we release the energy and the carbon that has been lying dormant.

WHAT WILL HAPPEN?

- As the planet warms, glaciers melt, the sea rises, weather patterns change and droughts and floods occur in different locations and intensities.
- These changes are unprecedented since humans inhabited this earth, but they have occurred through other causes in the millions of years before. We can see it in the fossil records where species became extinct, water covered much of the land we now live on and temperatures were much higher than today.
- The planet will probably survive what we are doing to it, but we may not.

LONG TERM RISK

- A risk is a bad event that might occur.
- A long term risk is a bad event that might happen far in the future.
- Climate change is full of Long Term Risks - excessive heat, drought, storms wildfires, floods and sea level rise.
- There is clearly uncertainty about where and when and the impact of these events. That is why we call this CLIMATE RISK!
- These are physical risks.
- We also face transition risks due to policies to mitigate climate change. These are even more uncertain as they depend upon the political process.

TRANSITION RISK

- Suppose we decide to stop emitting carbon into the atmosphere. What would happen?
- There would be a scramble to purchase solar panels and wind turbines and maybe nuclear reactors to generate power. Fossil energy companies would cease operations. Many others would be forced to adopt new technologies.
- The winners would be deluged with capital from investors and the losers would see their stock prices head toward zero.
- This is an example of transition - it is clearly a risk for some companies and an opportunity for others.

HOW DOES THE MARKET RESPOND TO CLIMATE RISKS?

- Asset prices are influenced by long run risks and rewards. An asset exposed to long run risk is less desirable than one that is not, all else being equal. It will therefore sell for less.
- Stocks exposed to climate risk trade at lower prices and higher expected return than similar stocks without these risks.
- This is important because these asset prices guide investment today. The cost of capital is greater for firms exposed to climate risk.
- If you think Long Run Risks do not matter, consider TSLA with P/E=59 and GM with P/E=5

EMPIRICAL EVIDENCE

- In a series of papers, Bolton and Kacperczyk(2021)(2023) have shown that returns on stocks with high or rising emissions are greater on average than other stocks after controlling for firm characteristics.
- Engle et al(2020) and De Nard et al(2024) point out that when there is news that climate is getting worse than the market expects, these stocks will fall in value as their risk increases. This provides a basis for forming and testing climate hedge/risk portfolios.
- So climate risk portfolios should outperform the market except when there is new information that the climate is getting worse.



HOW CAN WE REDUCE
CLIMATE RISK?

THE PARIS AGREEMENT

- Almost 10 years ago most nations of the world signed an agreement in Paris that committed them to make their economies emit no net emissions by 2050.
- It is a landmark departure from using the price of carbon as a target to using quantity of emissions as a target. Countries can choose their own approach to reach net-zero.
- Scientific research assures us that if the planet is entirely net-zero by 2050 we will avoid the worst damages of global warming.
- Commitments to net-zero emissions means that negative emission strategies can potentially be used to offset positive emissions.
- The agreement is not binding except as public pressure can enforce it or domestic legal actions can police performance.

HOW CAN WE REACH NET-ZERO? FOUR GOVERNMENT POLICIES for TRANSITION

- **TAX CARBON EMISSIONS**
 - E.g. cap and trade markets for emissions certificates as EU ETS
- **SUBSIDIZE RENEWABLE ENERGY and DECARBONIZATION**
 - E.g. Electric Vehicle subsidies or Carbon Capture and Sequestration Research as IRA
- **REGULATE EMISSIONS**
 - E.g. automobile emission standards or building code insulation
 - China regulation of fossil electricity generators and government build green tech
- **HOPE**
 - Hope that consumers, employees, investors and corporations will voluntarily adopt greener behavior!

TWO EXTERNALITIES

- Emissions of GHGs are clearly externalities as emissions are free but the costs are borne by the whole world
- Green Technology Innovations may also be an important externality. The more green technology is developed the cheaper it is for everyone to decarbonize.
- Acharya, Engle and Wang(2023) consider an economy with these two externalities. To achieve the best outcome in this case, two policies are needed – a carbon tax and an innovation subsidy.
- If either is constrained, the other will be unable to achieve the best outcome.

NET-ZERO COMMITMENTS

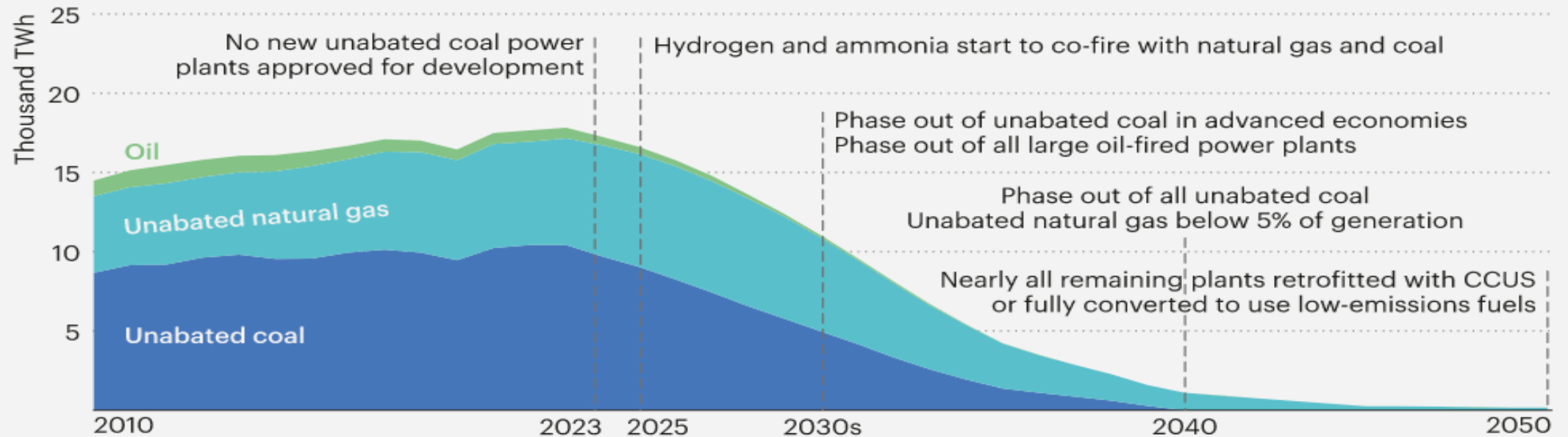
- Not only have countries committed to net-zero targets, also states, regions, cities, sectors and firms have voluntarily committed to net-zero.
- Why do they do this? They believe that such commitments will encourage customers to buy their products, employees to work for them, and investors to own their stocks. In addition, other economic agents may be incentivized to do the same to compete.
- A particularly interesting motivation is called a “Stackleberg Leader”. A company may commit to net-zero because the new technology that it develops will enable others to reduce emissions more cheaply and the planet will thus decarbonize faster leading to a lower carbon tax in the future. This benefits all including the leader. For this analysis, see Acharya et al(2023)

IEA MODEL FOR NET ZERO

Unabated fossil fuels in electricity generation

Electricity output from unabated fossil fuels falls by 40% to 2030 and virtually disappears by 2050, as plants are run less, retired, retrofitted with CCUS or repurposed to use low-emissions fuels.

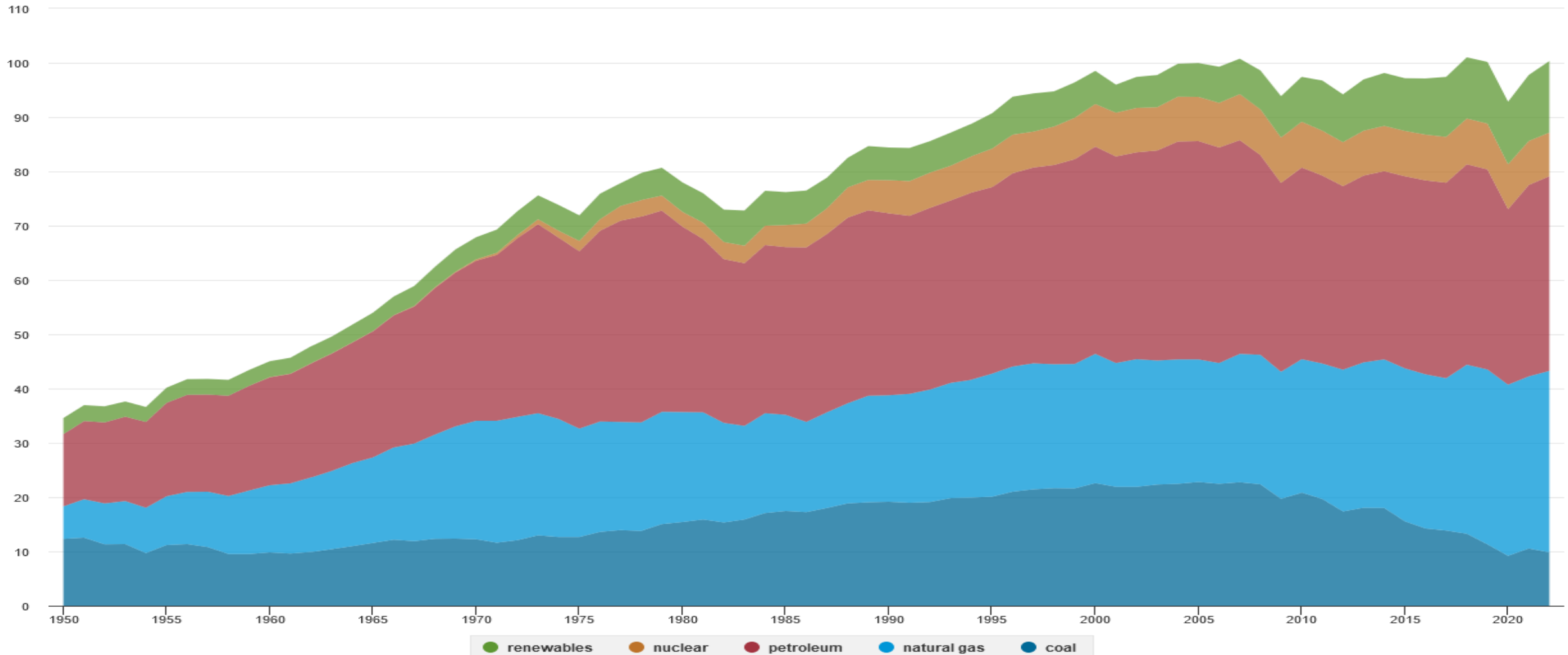
Unabated fossil fuels electricity generation



TOTAL US ENERGY CONSUMPTION IEA

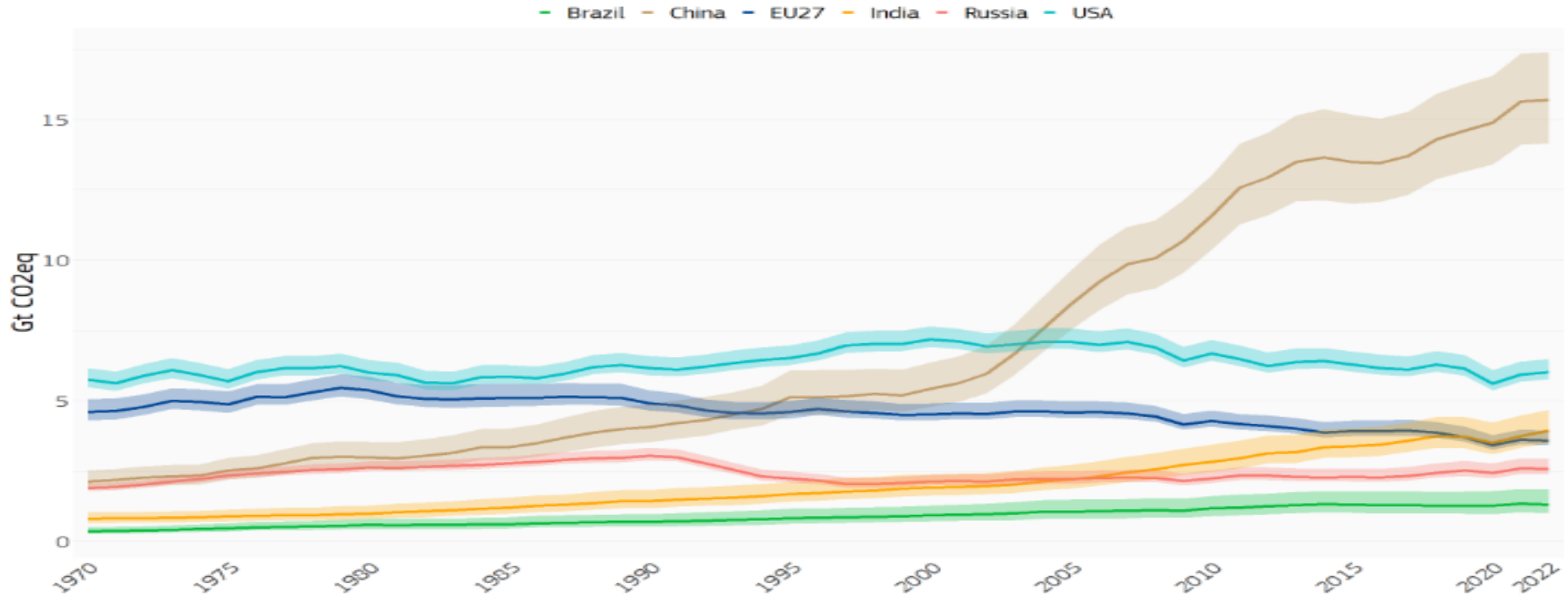
U.S. primary energy consumption by major sources, 1950-2022

quadrillion British thermal units



GHG EMISSIONS IN TOP EMITTING COUNTRIES

Figure 3. GHG emissions in top emitting economies and estimated uncertainty (coloured bands), 1970-2022, (in Gt CO_{2e})



Source: JRC, 2023



IMPACT of CLIMATE RISK on
FINANCIAL MARKETS

TODAY'S PRESENTATION

- Today I will show you results from VLAB
- VLAB.STERN.NYU.EDU
- This is the free web site of the Volatility and Risk Institute which is updated daily with measures of many different kinds of risks. The models in the paper and on VLAB are the same but there may be slight differences in presentation and certainly in sample period.
- Google *VLAB NYU* and then scroll down to *CLIMATE RISK*
- [VLAB](#)
- <https://vlab.stern.nyu.edu/climate/CLIM.WORLDFIN-MR.CMES>

FINANCIAL STABILITY MAY BE AT RISK

- Financial firms that hold assets which are exposed to climate risk, will fall in value if climate risk increases. This does not mean that it is realized – this can happen through expectations or scientific or political news.
- A bank that holds excessive climate risk may fail if the risk rises?
- However if many banks hold excessive climate risk, then climate risk event could cause a financial crisis. This is a macroprudential risk.
- One event that could dramatically increase transition risk would be a political decision to decarbonize quickly. It would be tragic if this decision to improve the future of the planet was responsible for a financial crisis.
- Regulators are seeking to reduce the exposure of the financial system to avoid this outcome.

Jung, Engle and Berner(2023) on CRISK

- To measure the sensitivity of financial institutions to climate risk, JEB estimate the climate beta on banks using a climate risk portfolio to measure the stress.
- When transition risk rises, a climate risk portfolio will decline since it is overweight stocks exposed to transition risk. Financials that are also exposed will also fall and will have a positive beta on such a risk portfolio.
- We will look at a stranded asset risk portfolio but have used others in corroborating the results.

$$SA_risk = .7 * KOL + .3 * XLE - SPY$$

EVALUATING MARKET STRESS TESTS

- The stress is that SA falls 50% over the next six months. This happens roughly 1% of the days since 2000. “extreme but plausible”
- The beta is measured by the regression for firm j :

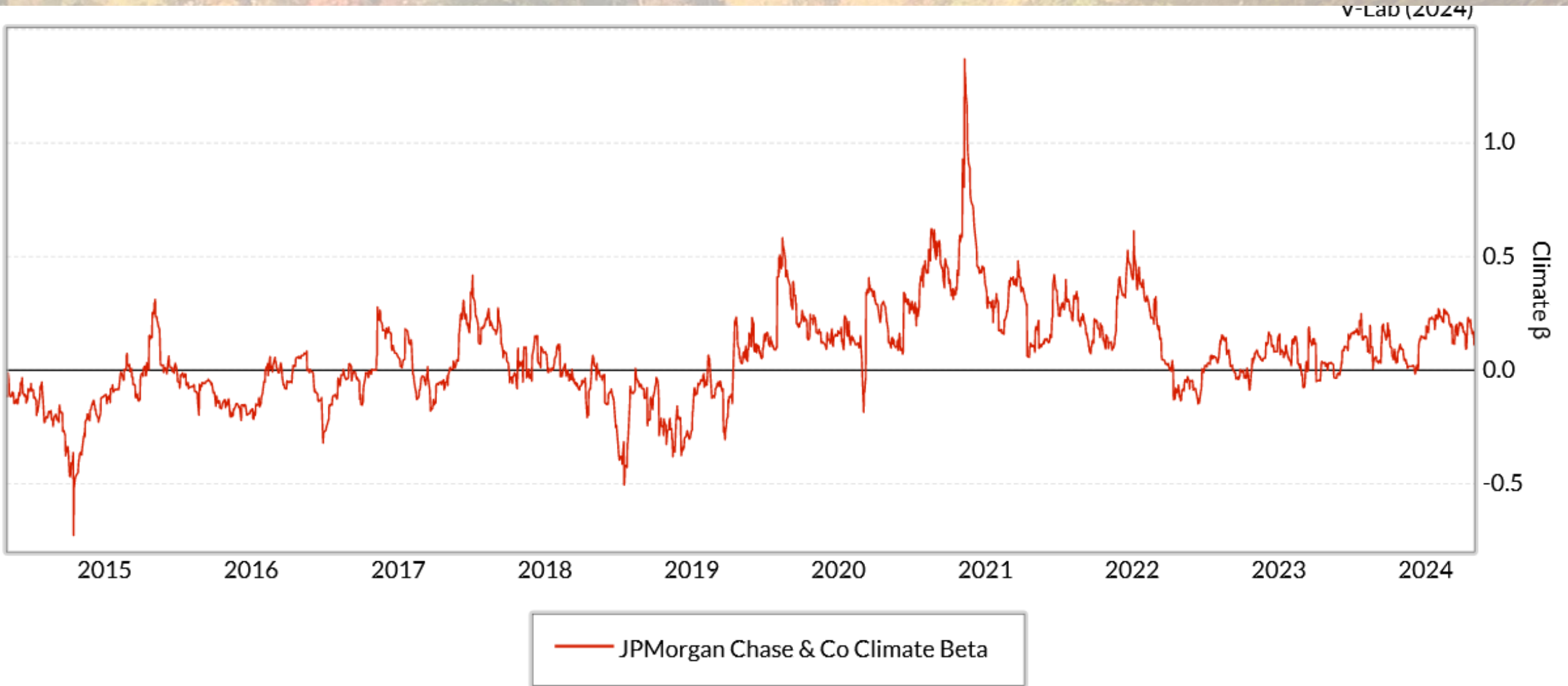
$$r_{j,t} = \beta_{t,j}^{SA} SA_risk_t + \beta_{t,j}^M Market_t + e_{j,t}$$

- where r is the return on financial j , SA_risk is the stranded asset risk portfolio and $Market$ is the all country world equity index, ACWI, the betas are allowed to vary over time taking account of changing volatilities and correlations with DCB (Dynamic Conditional Beta, Engle(2016) which is an extension of my Nobel Prize model).

CRISK AND MARGINAL CRISK

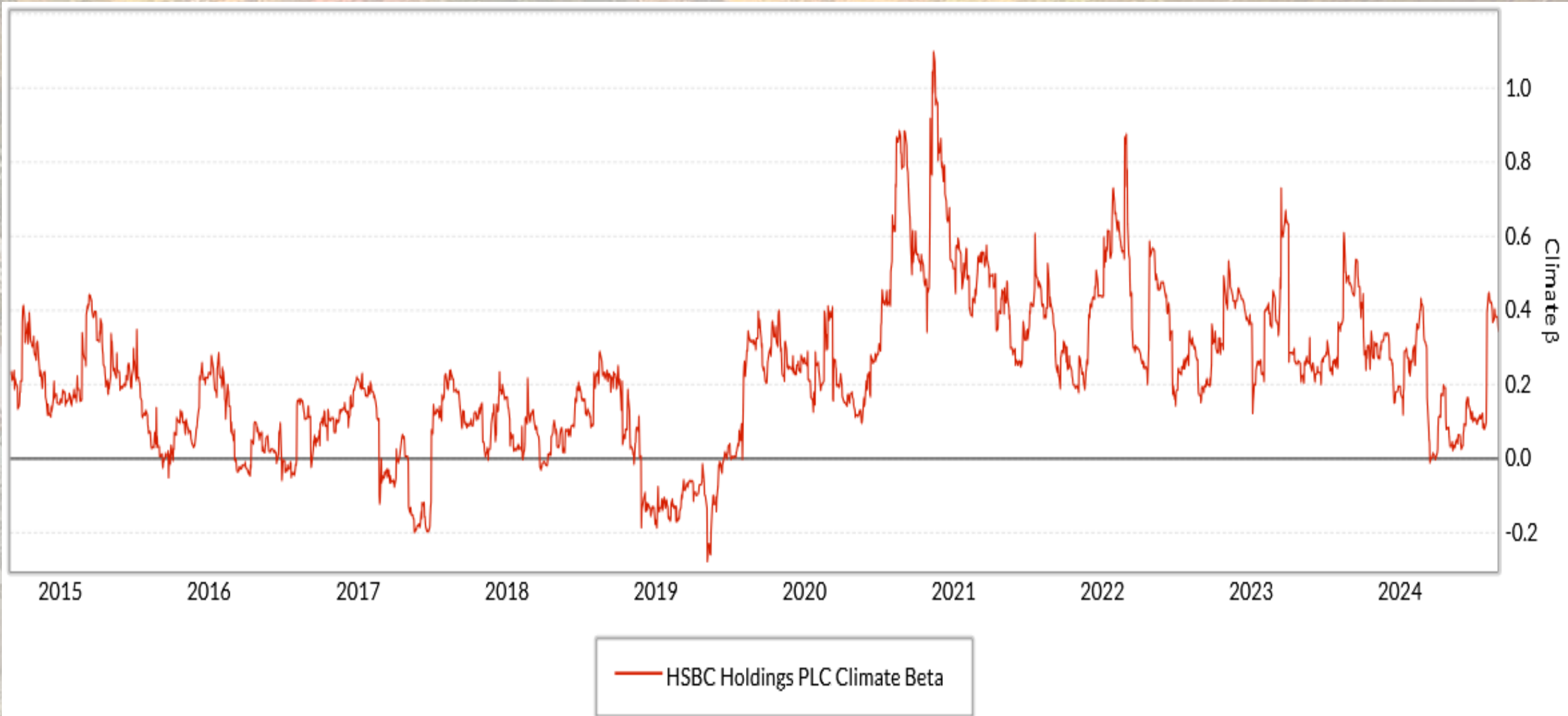
- CRISK is a measure of capital adequacy after a climate risk increase
 - It is an estimate of how much capital would be needed for the firm to continue to operate normally after a climate shock.
- Marginal CRISK is a measure of exposure to this risk.
 - This is an estimate of how much the market cap will fall if there is a climate stress

J.P.MORGAN CHASE CLIMATE BETA



HSBC CLIMATE BETA

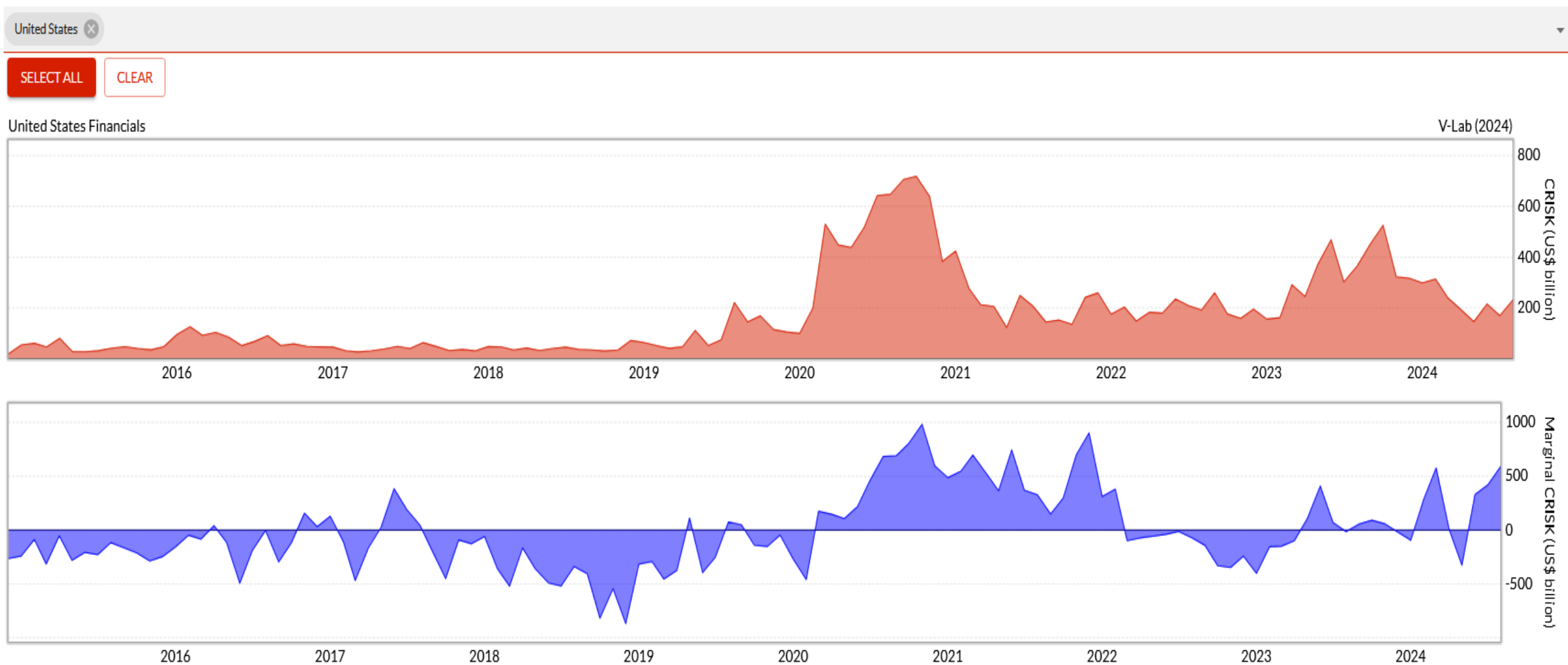
8/30/24



EU TOP MARGINAL CRISK: AUGUST 30, 2024

| Institution | CRISK % | CRISK (\$ m) | ↓ Marginal CRISK | LRMES | Climate β | Cor | Vol | Lvg |
|---------------------------------|---------|--------------|------------------|-------|-----------------|------|-------|-------|
| <u>Nordea Bank Abp</u> | 0.00 | -332819.7 | 77370.31 | 17.42 | 0.28 | 0.16 | 22.48 | 2.31 |
| <u>HSBC Holdings PLC</u> | 4.95 | 33598.4 | 29273.23 | 19.67 | 0.32 | 0.09 | 30.41 | 18.68 |
| <u>UniCredit SpA</u> | 0.00 | -3258.9 | 14905.39 | 24.20 | 0.40 | 0.17 | 36.80 | 13.11 |
| <u>Barclays PLC</u> | 11.56 | 78405.2 | 14573.54 | 35.75 | 0.64 | 0.22 | 33.88 | 45.09 |
| <u>BNP Paribas SA</u> | 13.67 | 92698.6 | 13907.78 | 19.12 | 0.31 | 0.19 | 23.39 | 36.79 |
| <u>Allianz SE</u> | 0.00 | -48637.4 | 13232.33 | 11.86 | 0.18 | 0.11 | 20.11 | 8.65 |
| <u>Banco Santander SA</u> | 6.33 | 42915.1 | 13092.18 | 18.88 | 0.30 | 0.15 | 29.13 | 25.57 |
| <u>Lloyds Banking Group PLC</u> | 3.98 | 26980.8 | 12596.36 | 28.28 | 0.48 | 0.14 | 29.02 | 23.73 |
| <u>ING Groep NV</u> | 1.48 | 10020.2 | 11272.74 | 20.58 | 0.33 | 0.13 | 27.48 | 17.79 |
| <u>Natwest Group PLC</u> | 3.08 | 20879.3 | 10992.63 | 30.98 | 0.53 | 0.12 | 38.07 | 22.97 |

US CRISK and MARGINAL CRISK



EU27 CRISK and MARGINAL CRISK

Countries

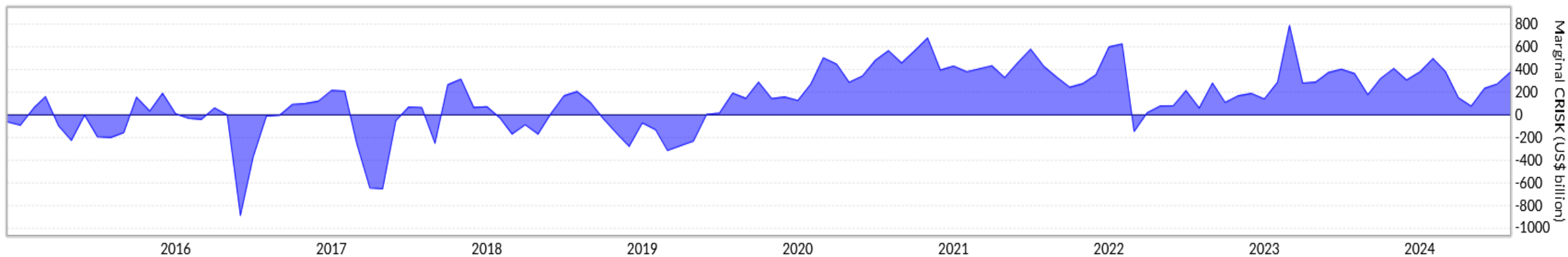
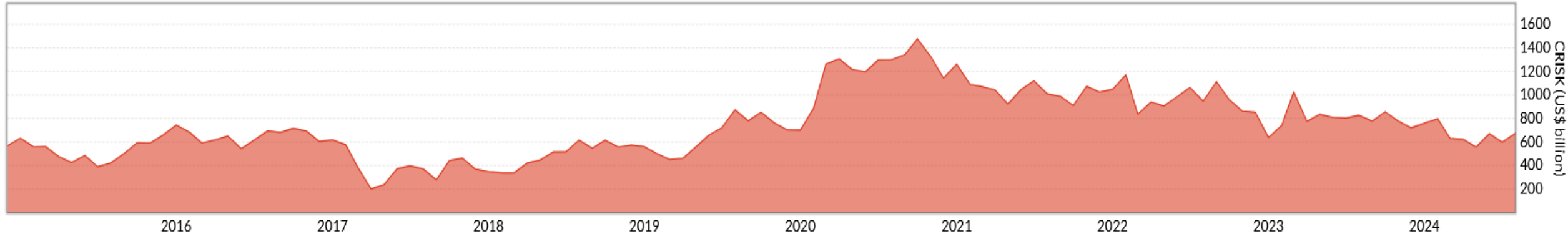
Austria x Belgium x Croatia x Cyprus x Czech Republic x Denmark x Estonia x Finland x France x Germany x Greece x Hungary x Ireland x Italy x Liechtenstein x Luxembourg x Netherlands x Norway x Poland x Portugal x Romania x Slovak Republic x Slovenia x Spain x Sweden x Switzerland x United Kingdom x

SELECT ALL

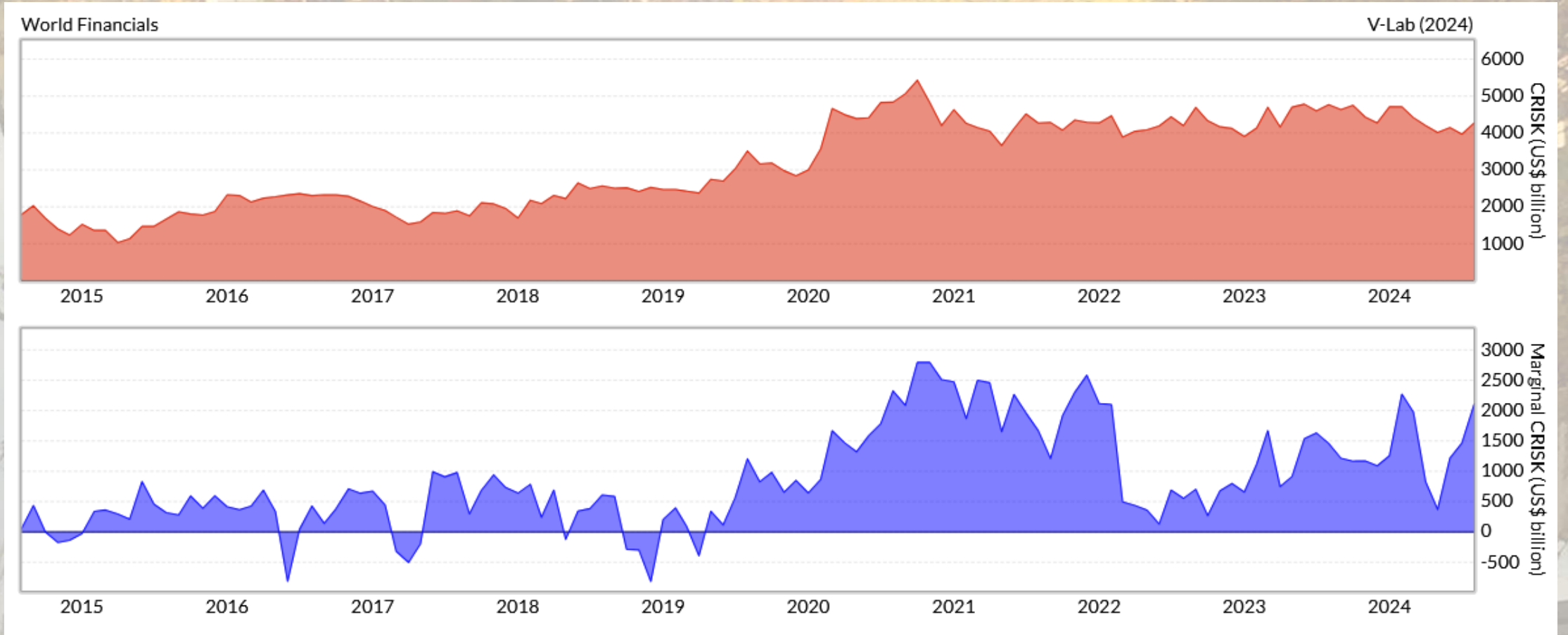
CLEAR

27 Selected Countries

V-Lab (2024)



WORLD CRISK and MARGINAL CRISK



WHAT DID WE LEARN?

- Today, most of the world financial firms are less exposed to climate risk than during the pandemic.
- The exposure to climate risk changes over time so we must monitor it. VLAB is a tool that can help.



TERMINATION RISK



THE ENGLSIDE

- The Engleside was a beautiful luxury beach front hotel on Long Beach Island in New Jersey.
- It failed from the great depression, from the invention of the automobile and from changing tastes for vacations.
- Similar hotels today face sea level rise and will ultimately be destroyed.
- **HOW SHOULD WE MANAGE SUCH A HOTEL?**

HOW SHOULD WE MANAGE THIS HOTEL?

- Sell if you can but you won't get replacement value.
- Do not upgrade if the payback period is long compared to the termination date. Reduce investment.
- Withhold maintenance improving the net income at least temporarily.
- If other hotels act the same, then the aggregate supply of beach front luxury rooms may shrink leading to increased room rates and possibly increased profits.
- Investors in this hotel should value their ownership based on the present discounted value of future expected cash flows up to the termination date adjusted for risk.

WHAT WE SHOULD SEE:

- **Falling Market Capitalization** and Enterprise Value from a declining business.
- **Low P/E** ratios as there are not many years left and there is risk.
- **Low P/B** ratios as the market value of the hotel is likely to be much less than its book value.
- **High expected returns** to the stock as risk compensation. Total Returns include dividend and stock buy backs.
- If demand increases, earnings will increase but supply will respond weakly.
- If the hotel has a mortgage, it will need insurance which will be very expensive.
- The manager might choose to diversify with the high cash flow, however unless there are important synergies, **investors would prefer cash back**. Furthermore, the high cost of capital would discourage such expansion.
- If some hotels cut their prices to increase business, then all will lose. We might expect **consolidation** to better harvest monopoly rents.



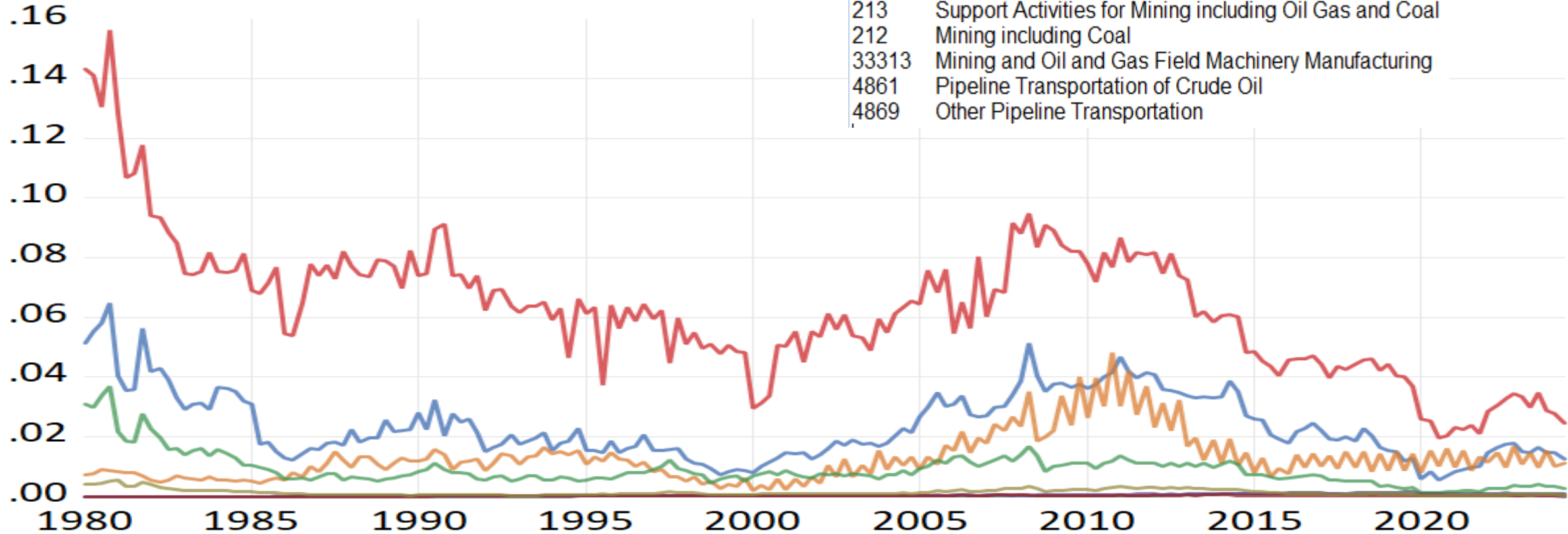
IS IT PLAUSIBLE THAT FOSSIL
ENERGY FIRMS FACE
TERMINATION RISK?

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MARKET CAP SHARES:US

| | |
|-------|--|
| 3241 | Petroleum and Coal Products Manufacturing |
| 211 | Oil and Gas Extraction |
| 213 | Support Activities for Mining including Oil Gas and Coal |
| 212 | Mining including Coal |
| 33313 | Mining and Oil and Gas Field Machinery Manufacturing |
| 4861 | Pipeline Transportation of Crude Oil |
| 4869 | Other Pipeline Transportation |



| | | |
|-----------|-----------|----------|
| — SH211 | — SH212 | — SH213 |
| — SH3241 | — SH4861 | — SH4869 |
| — SH23712 | — SH33313 | |

PE RATIOS MAY 3, 2024

| No. | Name | Market Cap | ^ P/E | Fwd P/E | PEG | P/S | P/B | P/C | P/FCF | EPS past 5Y | EPS next 5Y | Sales past 5Y | Change | Volume |
|-----|------------------------|------------|-------|---------|------|------|------|-------|-------|-------------|-------------|---------------|--------|---------|
| 1 | Energy | 3634.23B | 11.14 | 9.97 | 2.34 | 1.06 | 1.89 | 10.58 | 9.77 | 14.11% | 4.76% | 16.78% | 0.24% | 530.18M |
| 2 | Real Estate | 1427.23B | 11.19 | 27.21 | 1.45 | 3.98 | 2.07 | 17.85 | 18.97 | 4.27% | 7.71% | 42.89% | 0.71% | 381.83M |
| 3 | Financial | 10190.01B | 13.39 | 12.85 | 1.32 | 1.84 | 1.63 | 11.86 | 8.36 | 24.62% | 10.18% | 16.47% | 0.30% | 902.47M |
| 4 | Utilities | 1395.70B | 19.18 | 15.32 | 2.23 | 2.07 | 1.83 | 23.23 | 75.58 | 5.67% | 8.59% | 6.23% | 1.24% | 176.26M |
| 5 | Basic Materials | 2070.06B | 22.15 | 14.47 | 2.63 | 1.71 | 2.17 | 12.04 | 20.92 | 8.15% | 8.43% | 10.75% | 0.95% | 387.19M |
| 6 | Consumer Cyclical | 7247.95B | 23.07 | 18.12 | 1.25 | 1.62 | 4.38 | 8.99 | 29.38 | 15.41% | 18.41% | 30.95% | 0.93% | 1.23B |
| 7 | Communication Services | 7603.21B | 23.84 | 17.44 | 1.22 | 3.32 | 4.05 | 13.98 | 20.87 | 14.77% | 19.56% | 232.17% | 0.86% | 613.14M |
| 8 | Consumer Defensive | 3798.33B | 24.36 | 18.37 | 2.78 | 1.31 | 4.43 | 21.17 | 21.06 | 8.00% | 8.77% | 6.80% | 0.36% | 381.14M |
| 9 | Industrials | 5484.65B | 25.22 | 18.51 | 2.23 | 1.97 | 4.55 | 17.59 | 26.77 | 10.44% | 11.29% | 8.59% | 0.74% | 891.05M |
| 10 | Healthcare | 7813.02B | 37.16 | 18.03 | 2.38 | 1.96 | 4.42 | 16.17 | 27.64 | 6.20% | 15.61% | 67.26% | 0.23% | 1.38B |
| 11 | Technology | 17546.62B | 37.38 | 24.30 | 2.07 | 5.87 | 8.22 | 21.07 | 34.54 | 24.28% | 18.06% | 18.94% | 2.69% | 1.49B |

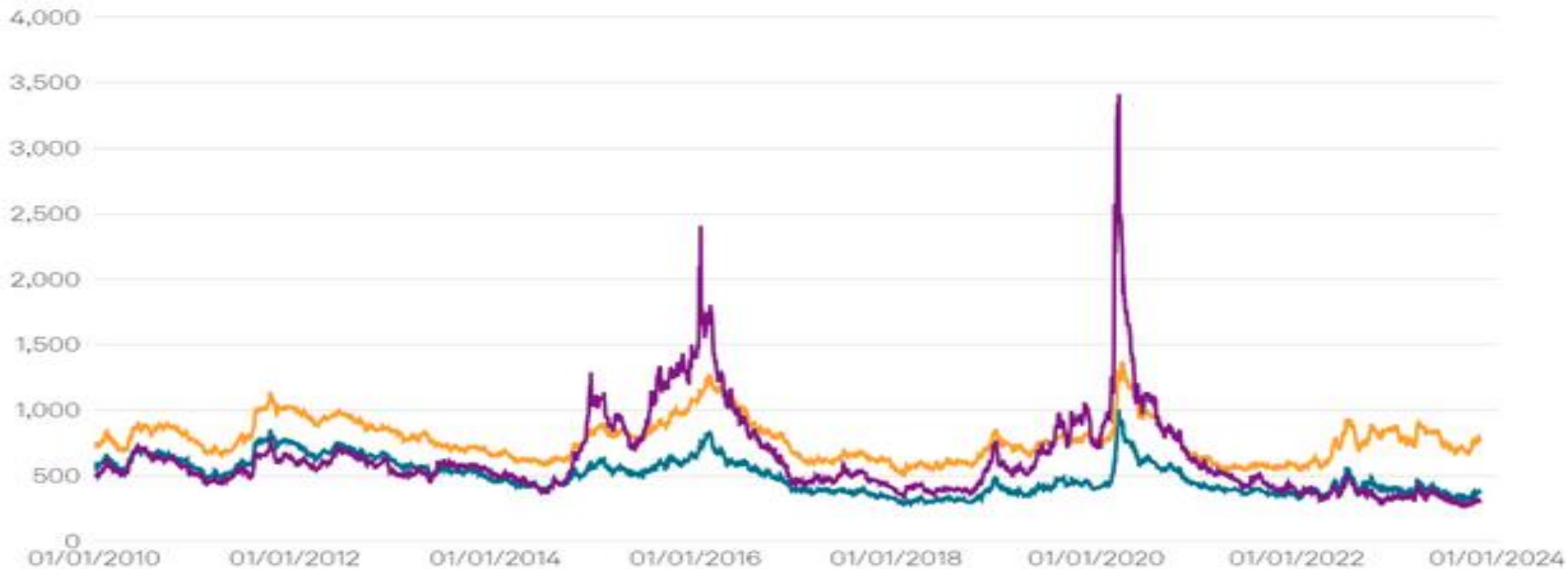
Chart 3b

Speculative-grade oil and gas spreads versus nonfinancial sector

(basis points)

■ Speculative grade, nonfinancial, five year
■ Speculative grade, oil and gas, five year

■ B- and below, nonfinancial, five year



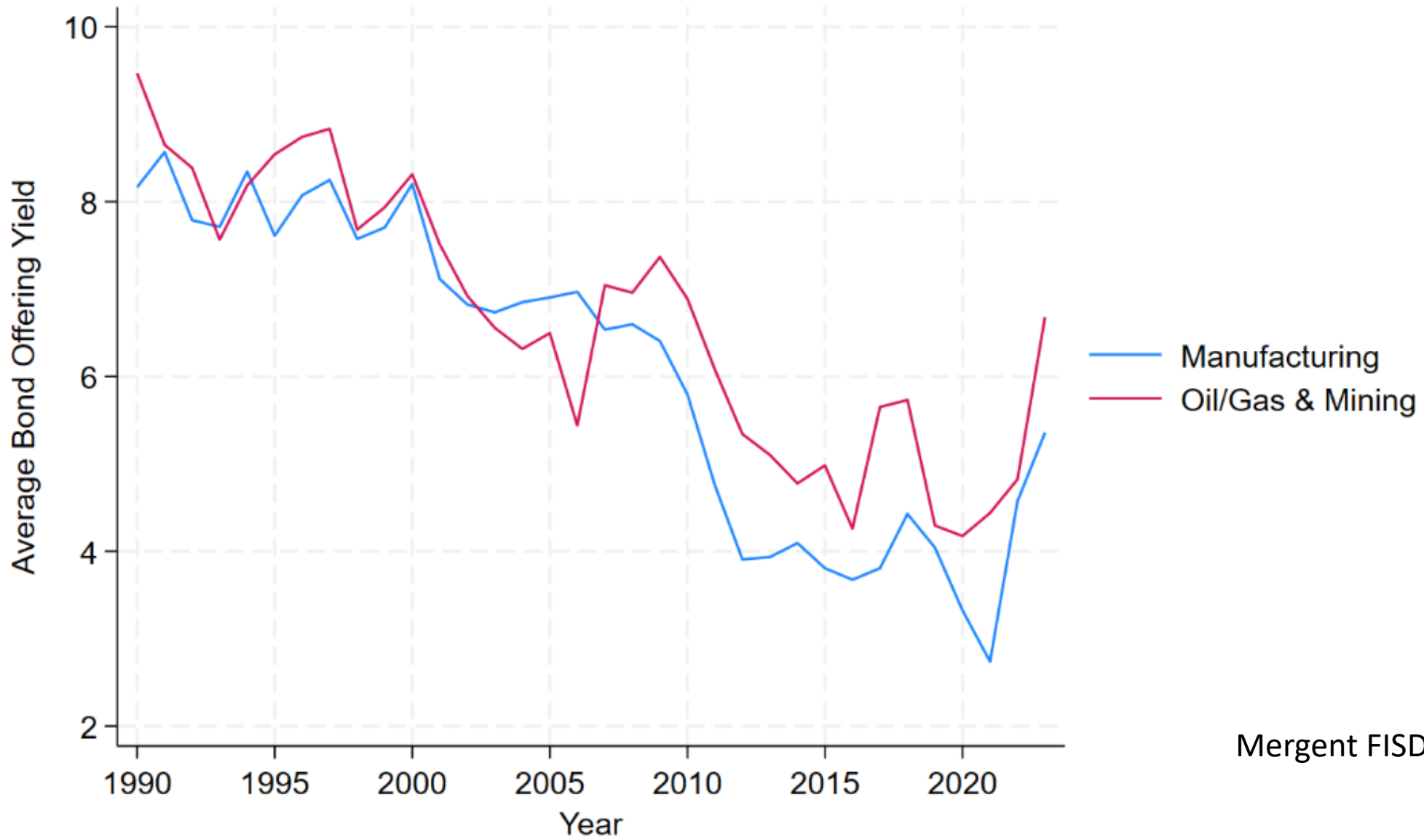
Data through Oct. 31, 2023.

Chart shows the option-adjusted spread for US corporate bonds with a five-year maturity.

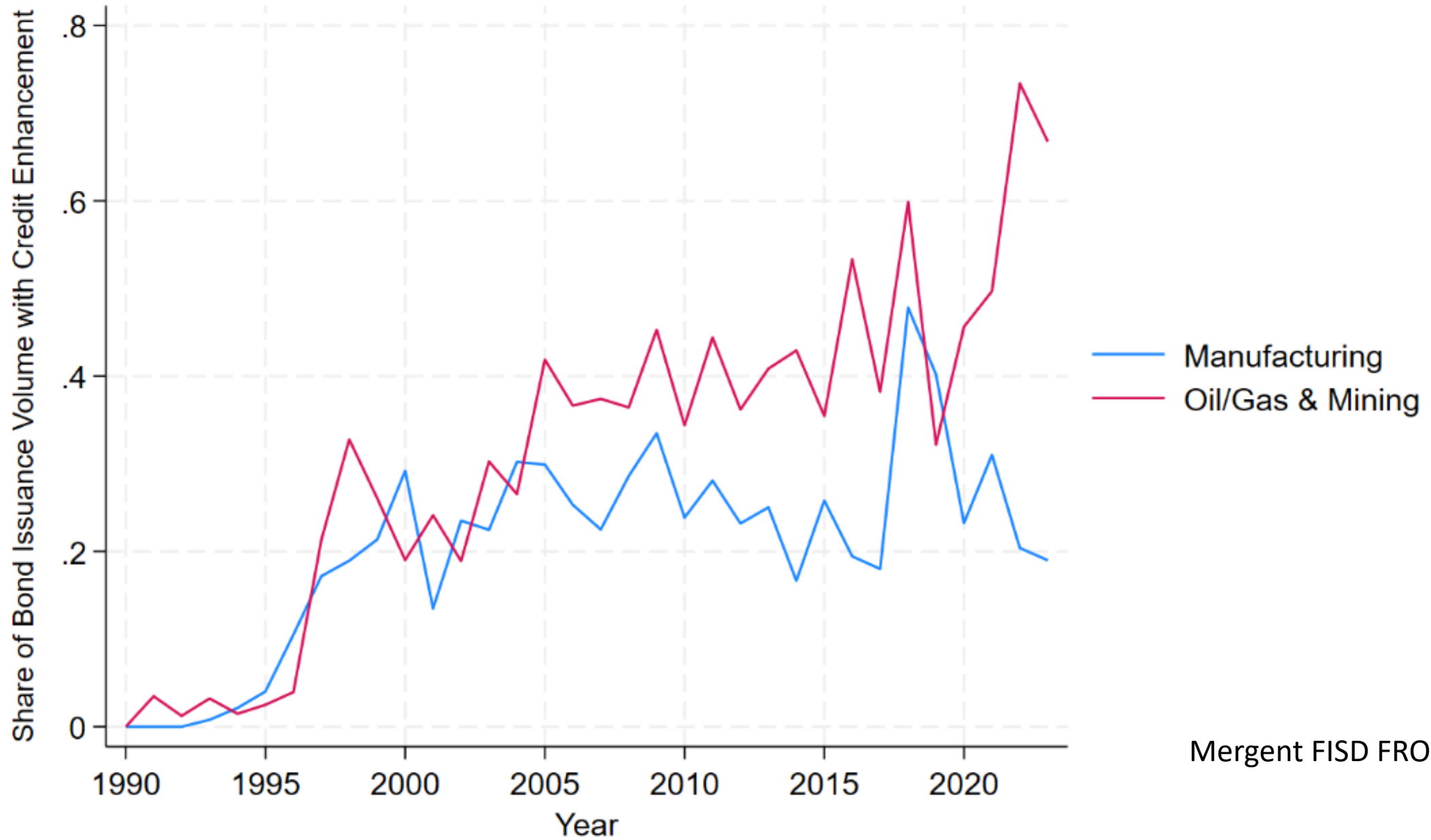
Source: S&P Global Ratings Credit Research & Insights.

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Figure 4: Bond Offering Yield Comparing Oil/Gas & Mining against Manufacturing

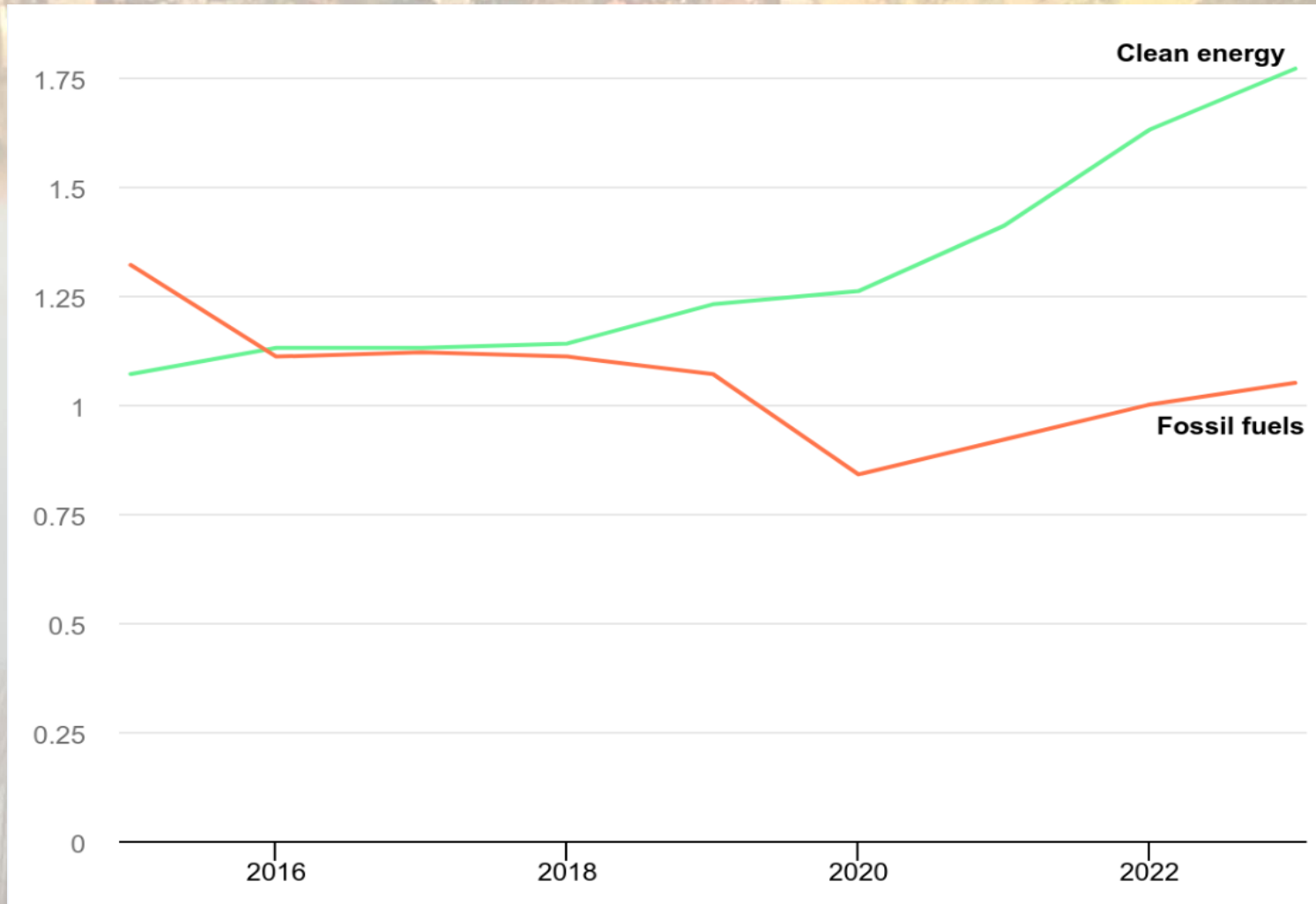


Mergent FISD FROM WRDS

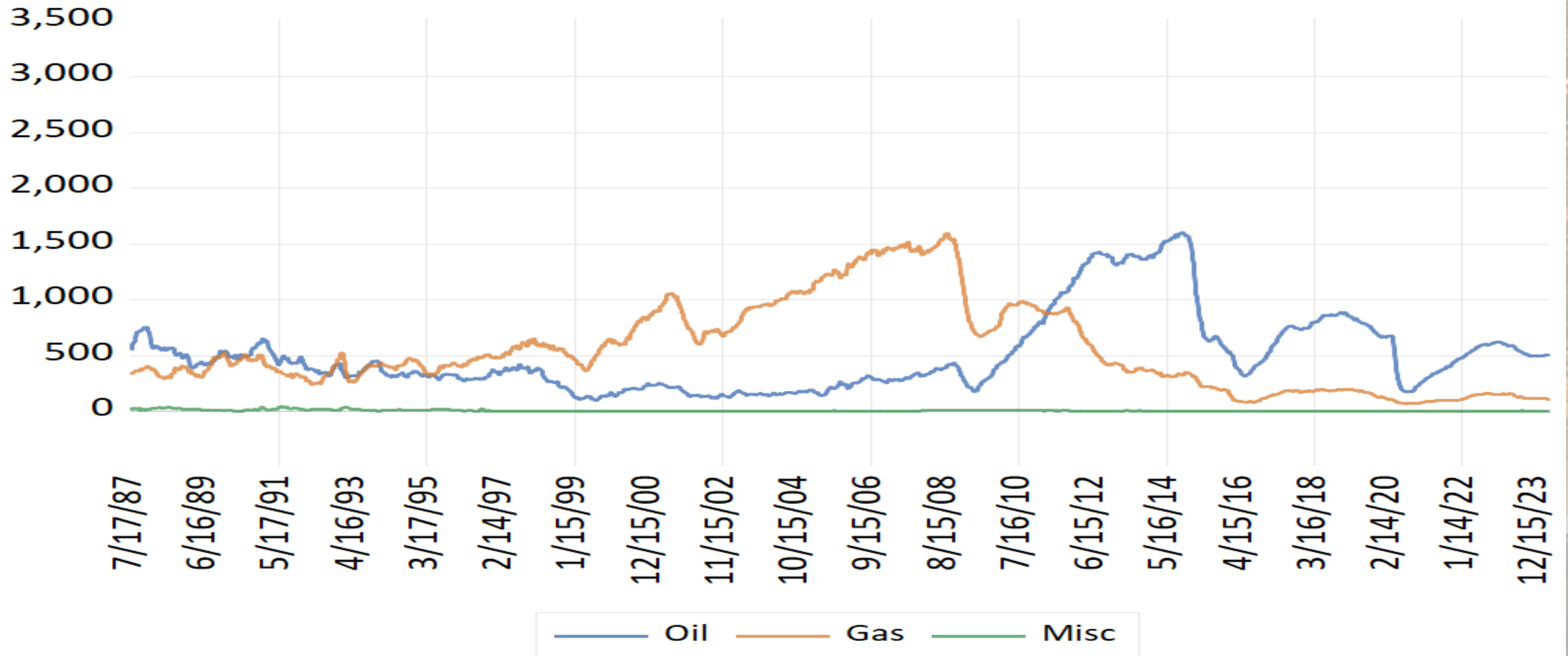


Mergent FISD FROM WRDS

Annual Global Investment



OIL and GAS US rotating rigs from Baker Hughes



GLOBAL CHANGE IN RIG COUNT

Baker Hughes 

INTERNATIONAL Yearly Rig Count

| Region | 2023 | 2024 | Yearly chg | Yearly chg% |
|--------------------|-------------|-------------|------------|-------------|
| Africa | 102 | 110 | 7 | ↑ 7% |
| Asia-Pacifi | 217 | 223 | 6 | ↑ 3% |
| Europe | 118 | 119 | 1 | ↑ 1% |
| Latin Ameri | 178 | 163 | -16 | ↓ -9% |
| Middle East | 332 | 345 | 13 | ↑ 4% |
| <i>Internation</i> | <i>948</i> | <i>959</i> | 12 | ↑ 1% |
| North Ameri | 864 | 784 | -81 | ↓ -9% |
| <i>Worldwide</i> | <i>1812</i> | <i>1743</i> | -69 | ↓ -4% |

LITTLE EFFECTIVE DIVERSIFICATION

- Environmentalists often accuse big oil companies of not developing renewable energy projects.
- Solar and Wind projects are not where oil fields are found. Pipelines and the electric grid are quite different. There may be few synergies between fossil energy and renewable energy.
- If fossil energy develops renewable subsidiaries, they might best profit by selling them at a green premium rather than keeping them.

MERGERS AND ACQUISITIONS

- 2023 EXXONMOBIL purchased PIONEER NATURAL RESOURCES \$64B
- 2023 CHEVRON purchased HESS CORP \$60B
- 2019 OCCIDENTAL PETROLEUM purchased ANADARKO \$55B
- This is both termination for the acquired company and consolidation for the acquiring company. No net expansion of the industry.



IMPLICATIONS

IMPLICATIONS FOR CLIMATE MITIGATION

- Rising fossil energy prices and profits lead many climate hedge portfolios to underperform.
- Rising fossil energy prices are important signals to change product mix to greener and less expensive inputs.
- If fossil energy firms are indeed planning for possible termination, this will align with the Paris Agreement.
- Hedge portfolios should still provide a hedge since information that termination is coming sooner will make stocks decline. If they ultimately go to zero, hedge portfolios should outperform.

COUNTRIES MAY FACE TERMINATION RISK OF THEIR MAJOR INDUSTRY

- This is the case in many middle eastern countries.
- They are actively seeking to diversify their economies with the added profits from reduced investment and supply which have lead to high energy prices. We see expenditures on leisure, sports, arts, education, travel and many other categories.

RUSSIA

- Russia also faces termination risk for its oil and gas business.
- Putin also wants to diversify his economy but has chosen to invade Ukraine to get access to other resources and export industries. This unlawful and inhumane strategy has been coupled with a reduction in energy supply which has ultimately resulted in higher profits and prices.
- He must recognize that his oil and gas business will be worth less in a decade and that Europe will be less dependent upon Russian fossil energy in a decade. He is in a hurry.
- It does not appear to be a successful strategy.

IRAN

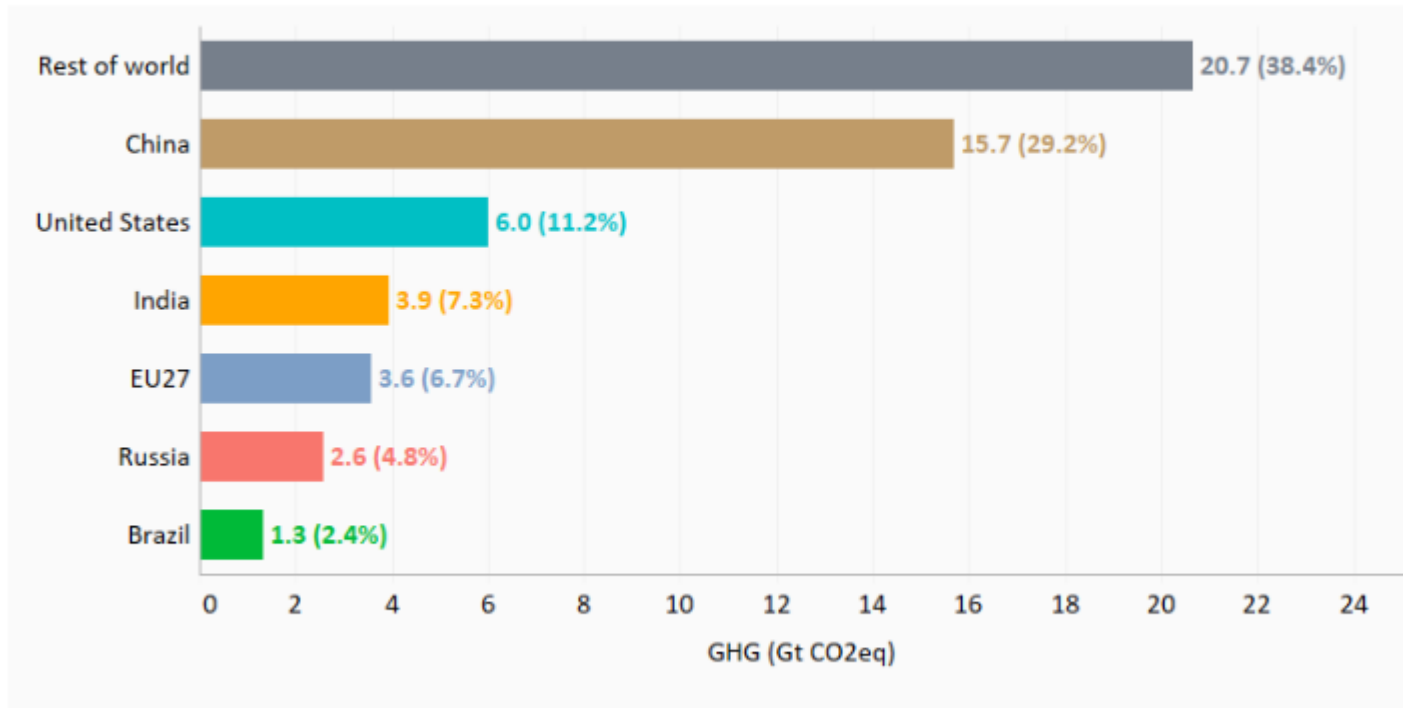
- Iran is using its excess profits to disrupt the middle east.
- This strategy is unlikely to replace the oil and gas revenue in the event that termination risk materializes.

CLIMATE CONSEQUENCES

- Fossil energy firms that restrict supply and investment are aiding the decarbonization process.
- Putin is certainly accelerating the decarbonization of Europe.
- The IRA is stimulating renewable energy in the US and that will ultimately be very competitive with fossil energy.
- The Green Deal in Europe is also driving climate mitigation.
- And China is investing heavily in green technology even as it expands electrical generation with fossil energy. It has set up a full system of cap and trade emission allowances although it has not yet come to full power. And it is a market leader in solar panels and electric vehicles among other green products.

MAJOR GHG EMITTERS 2022

Figure 1. GHG emissions (in Gt CO_{2eq}) and contribution of the major emitting economies and the rest of the world in 2022, (in Gt CO_{2eq})



Source: JRC, 2023

The Human Species also Faces Termination Risk

- We may make the planet uninhabitable for humans.
- The solution to this risk is only to reduce its probability.
- The Paris Agreement has set out a roadmap. We need to follow it by honoring our commitments.
- The most important part is that the biggest emitters work together to achieve net zero economies by mid century. This means US, China, Europe and India. If these four countries can collaborate and coordinate, then the worst outcomes can be avoided and most of the developing nations of the world will join in this effort and will benefit from the advanced decarbonization technology developed.

CONCLUSIONS

- To reduce the expected damages from climate change, we must transition to a lower carbon economy.
- This costly transition will be amply funded by private capital if it appears profitable.
- Public policy through subsidies, taxes, and regulation can create the needed conditions.
- Political leaders must be willing to carry out the required policies. Only then can we be confident that our children and their children will have a healthy planet to live on.

What kind of world will
we inherit?





But if we can
tell them that
we have it
solved,