

Climate and the risk of stranded assets: portfolio management in Norway



NORWAY'S CLIMATE RISK COMMISSION

**POTENTIAL CLIMATE RISKS IN FINANCIAL
MARKETS**

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OUTLINE



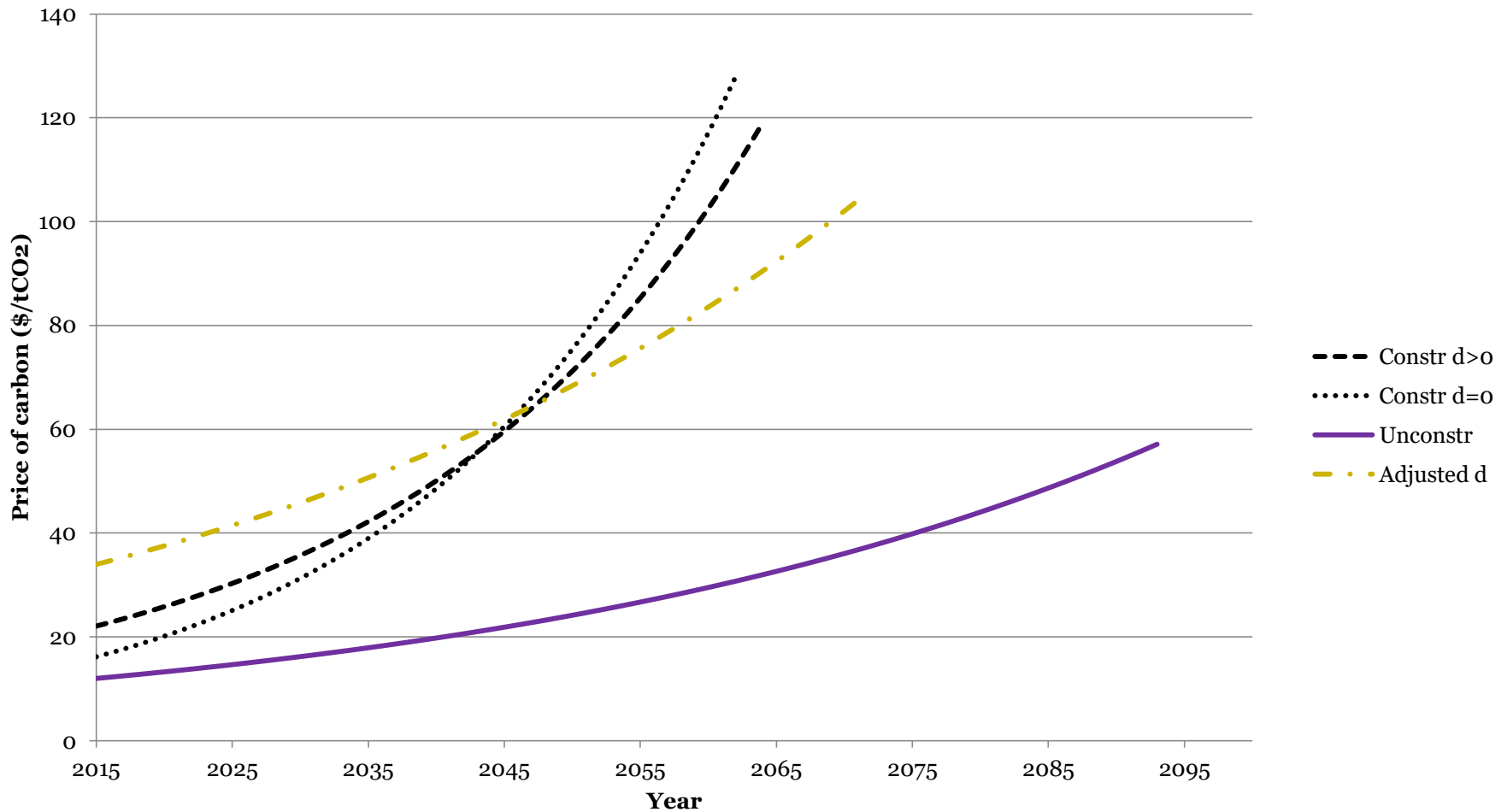
- The Safe Carbon Budget
- What policies ensure that it is not violated.
- Risk of stranded assets: in fossil fuel industries but also in industries that rely on fossil fuel as input.
- Principles of managing oil and gas wealth for future generations: bird in hand versus permanent income.
- Extending this to allow for climate.
- Hedging climate risks.

PEAK WARMING & THE SAFE CARBON BUDGET



- Peak warming is directly related to cumulative emissions: $PW = \alpha + TCRE \times E$.
- So if cap of 2 degrees, then safe carbon budget is equal to $E = (2 - \alpha)/TCRE$.
- With $\alpha = 1.276$ and $TCRE = 2$, we get safe carbon budget of $362 \text{ GtC} = 1,327 \text{ GtCO}_2$.
- A cap of 1.5 degrees $\rightarrow 112 \text{ GtC}$ or 411 GtCO_2 .
- Note: more recent data Point of No Return has passed.
- Price carbon at Hotelling rate as carbon gets 'scarcer' as budgets gets closer to exhaustion provided welfare maximisation gives $PW > 2$ degrees.

Constrained and unconstrained climate policies



Low risk tolerance and tight cap on peak warming \rightarrow low safe carbon budget

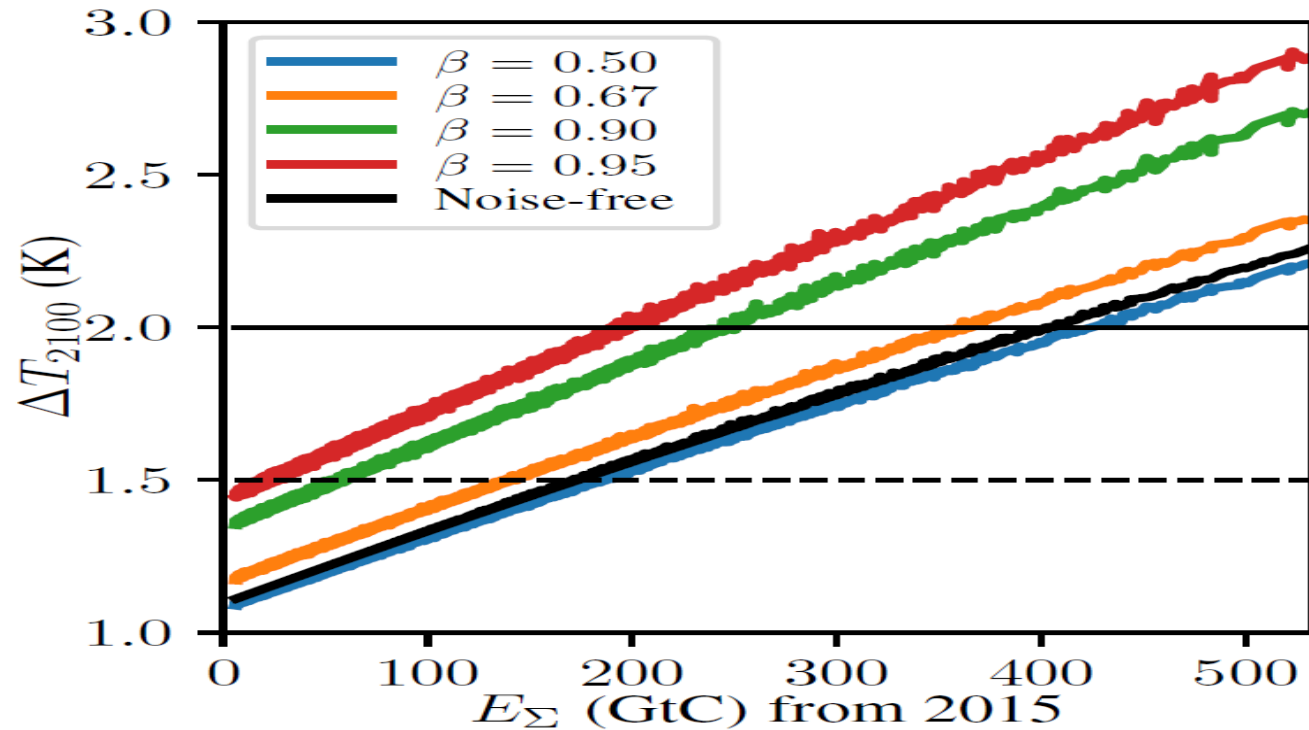


Figure 2 T_{max} in 2100 such that $p(\Delta T_{2100} \leq T_{max}) = \beta$ as a function of cumulative emissions for different β . Black curve gives deterministic results with noise terms set to zero.

Safe carbon budget (GtC) since 2015



β	0.5	0.67	0.9	0.95	Noise-free
$T_{max} = 1.5 \text{ K}$	185	140	57	22	173
$T_{max} = 2.0 \text{ K}$	424	361	245	196	404

Table 1: Safe Carbon Budget (in GtC since 2015) as function of threshold and safety probability β .

Point of no return depends on particular emission scenarios



- How many years are left before climate policy becomes infeasible (i.e., before the stochastic temperature target becomes unreachable) is the point of no return.
- Extreme mitigation (EM, blue): m is 1 from some time onwards.
- Fast mitigation (FM, orange): both a and m increase by 5% per year, so zero emissions in less than 20 years.
- Ambitious mitigation (AM, green): FM but 2% per year.
- The faster the rate of emission reductions the further away the point of no return.

Point of no return comes closer if risk tolerance and cap on peak warming are tighter



β		0.5	0.67	0.9	0.95	noise-free
EM	$T_{max} = 1.5 \text{ K}$	2031	2028	2021	2018	2031
	$T_{max} = 2.0 \text{ K}$	2047	2043	2036	2033	2046
FM	$T_{max} = 1.5 \text{ K}$	2025	2022	–	–	2024
	$T_{max} = 2.0 \text{ K}$	2040	2037	2030	2026	2039
AM	$T_{max} = 1.5 \text{ K}$	–	–	–	–	–
	$T_{max} = 2.0 \text{ K}$	2030	2026	2019	2016	2029

Table 2: Point of No Return as function of threshold and safety probability β .

UNBURNABLE FOSSIL FUEL TO KEEP TEMPERATURE UNTIL 2050 BELOW 2 °C



- Globally keep 1/3 of oil (Canada, Arctic), 1/2 of gas and 4/5 of coal (mainly China, Russia, US) reserves unburnt. Reserves are 3x and resources 10-11x the carbon budget. In Middle East 260 billion barrels of oil that should not be burnt (McGlade and Ekins, 2015).

BURN NOTICE WARNING ON ENERGY RESERVES

Regional distribution of reserves to remain unburned in order to avoid exceeding the 2°C “safe” threshold for global warming before the year 2050

	% OIL	% GAS	% COAL
MIDDLE EAST	38	61	99
OECD PACIFIC	37	56	93
CANADA	74	25	75
CHINA & INDIA	25	63	66
CENTRAL & S AMERICA	39	53	51
AFRICA	21	33	85
EUROPE	20	11	78
US	6	4	92

Note of optimism

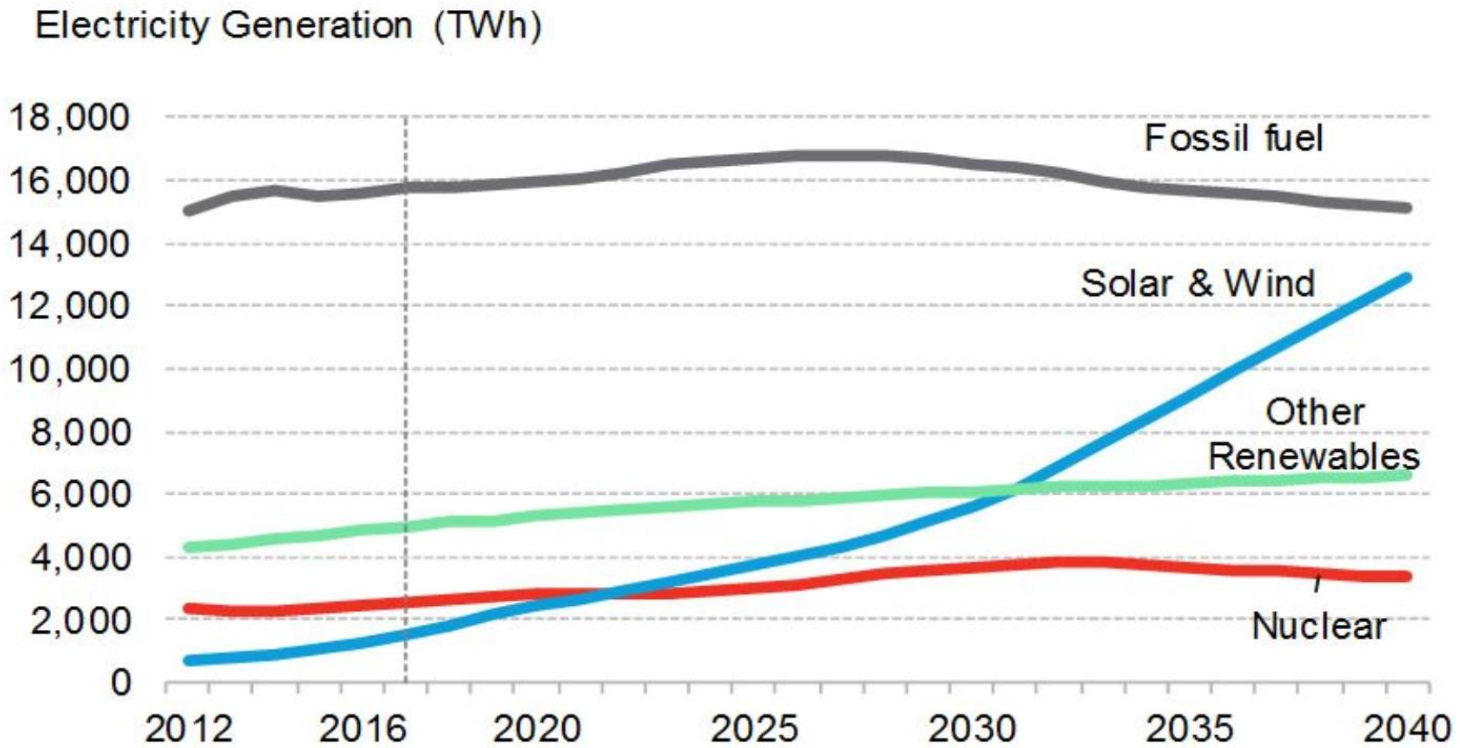


- Solar energy costs dropping by a further 66% by 2040, onshore wind by 47% with renewable undercutting the majority of fossil power stations by 2030 (New Energy Outlook, 2017, Bloomberg).
- Global emissions peak in 2026 and 4% lower in 2040 than in 2016. Already not much change ...
- Greening of world's electricity system is unstoppable due to better batteries and new sources of flexibility. Electric vehicles help balance the grid.
- In US: coal-fired electricity will drop by 51% despite Trump, gas-fired and renewable-fired will rise by 22% and 169%.

Technological progress may do the job



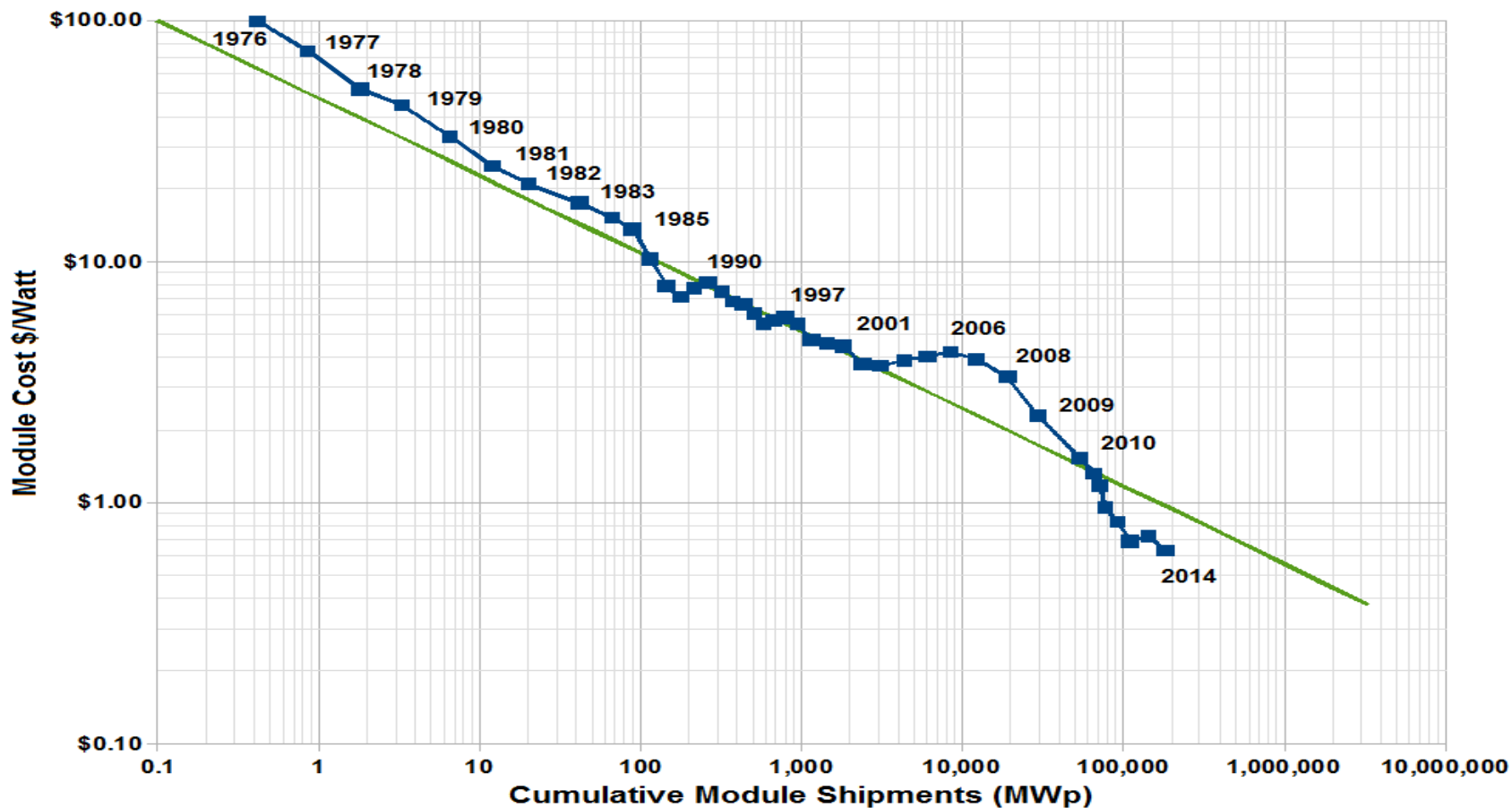
Figure 1: Global electricity generation mix to 2040



Learning curve: cost of solar panels drops 20% for every doubling of cumulative shipped volume



Swanson's Law



RISK OF STRANDED CARBON ASSETS



- Reserves of the big oil and gas companies are much bigger than the safe carbon budget, and that is not counting reserves of the state companies. Further, still new investment in fossil fuel including shale gas.
- If announced climate policies are really credible, there is a serious risk of stranded fossil fuel assets – so short the oil and gas majors?
- Big sovereign risk for gas-exporting countries like Russia, Nigeria, Algeria and .. Norway. Race to burn the last ton of carbon? Green Paradox: accelerate global warming.
- In any case, ongoing explosion of carbon discoveries and reserves cannot go on if planetary warming has to stay below 2 degrees Celsius. So need carbon pricing and climate club. And investors need to anticipate this.

Irreversibility and stranded assets



- Yes, coal, oil and gas will have to be locked up in the crust of the earth.
- But does this mean that big oil and gas companies such as Gazprom, BP or Shell have to write off large chunks of assets on their balance sheet or go bankrupt? Only if they cannot easily reverse their past exploration and exploitation investments. Unlikely.
- Also, **irreversible** investments in say coal-fired electricity power stations will have to be written off. So many industries locked into carbon-based capital will be hit unless they become green.

Why do assets get stranded?



- (1) surprise intensification of climate policy & (2) irreversibility of investments in dirty capital stocks.
- Stranded assets imply scrapping of dirty capital and potential falls in share prices of carbon-based industries. Hence, **carbon bubble**.
- Dirty and clean capital in final goods production.
- Carbon-based investments in electricity generation.
- E.g., exploration and exploitation investments by the oil, gas and coal industry, and need to lock up carbon in crust of the earth.

Stranded capital in the power industry



- Pfeiffer et al. (2016) define the “2°C capital stock” as the global stock of infrastructure which, if operated to the end of its normal economic lifetime, implies warming of 2°C or more (with 50% probability).
- Using IPCC carbon budgets and the AR5 scenario, they show that the “2°C capital stock” will be reached in 2017 even when other sector do their share of staying below 2°C. Hence, no new emitting infrastructure can be built anymore unless other infrastructure is scrapped or retrofitted with CCS!
- Pfeiffer et al. (2017) show that keeping warming below 1.5-2°C cuts utilisation of coal-fired electricity in the period up to 2050 from 60 to 29%.

Financial markets



- Andersson et al. (2016) argue that the cost of hedging against the risk of climate policy suddenly being toughened with carbon-free trackers is now very small indeed as the market is not anticipating it. Do this by investing in carbon-free tracker indices (e.g., MCCC).
- Bansal et al. (2016) use real market data in the U.S. to estimate the negative impact of long-run shifts in temperature on share prices.
- Carbon Tracker Initiative (2011) suggests 20-30% of the market capitalisation of the stock exchanges of London, San Paolo, Moscow, Australia and Toronto is fossil fuel based. Need much more research in vulnerability to carbon risks.

Hedging climate risks



- Litterman (2012): tail risk and the price of carbon.
- Should policy makers focus at correlations or worst-case scenarios?
- CAPM insight: stocks that show positive or non-falling returns when oil price collapses or climate policy tightens are used to hedge.
- Divestment of all fossil fuels is a blunt instrument to hedge. Note also that gas may play role in transition.
- Use swaps and other financial derivatives?

Time scale and hedging climate risk



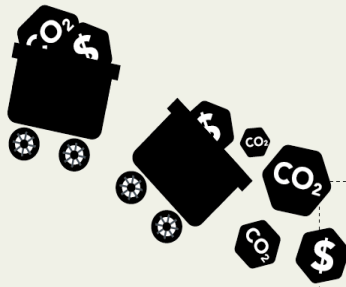
- Climate risks are very, very far in the future.
- So need to use **very low** discount rates for discounting benefits say 100 years from now: Martin Weitzman.
- Cannot infer discount rates from market rates of return.
- A climate hedge is an investment project that yields a really big return in 100 or 200 years if global warming then turns out to be much hotter than expected. What are these projects apart from dykes, water defences, etcetera? Problem: “maturity mismatch”.
- Climate beta is close to one in most integrated assessment models. Not clear that this is realistic.

Oversight and regulatory authorities



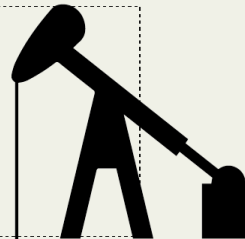
- Governors of central banks have warned for carbon bubbles and financial and fiduciary risks of holding large investments in fossil fuel; e.g., Carney (2015).
- Insurance companies and especially pension funds should be concerned too.
- Need 2°C stress tests for investment portfolios!
- Not clear which capital market regulators are held responsible for carbon-related systematic risks and who is responsible for ensuring that full corporate disclosure of carbon risks takes place.
- Follow Sweden and the divestment campaign?

Investors and markets are at risk from \$2.2 trillion of stranded fossil fuel assets



Coal is the most carbon intensive fossil fuel. No new coal mines will be needed and nearly **\$220bn** of projects are at risk.

Oil demand will peak around 2020 and more than **\$1.4 trillion** of projects are at risk.



Growth in gas will disappoint industry expectations, especially in expensive LNG. Planned spending of more than **\$520bn** is at risk.



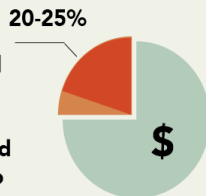
Which are the companies with most financial exposure?

We identified the **20 companies** with most capex in the danger zone.

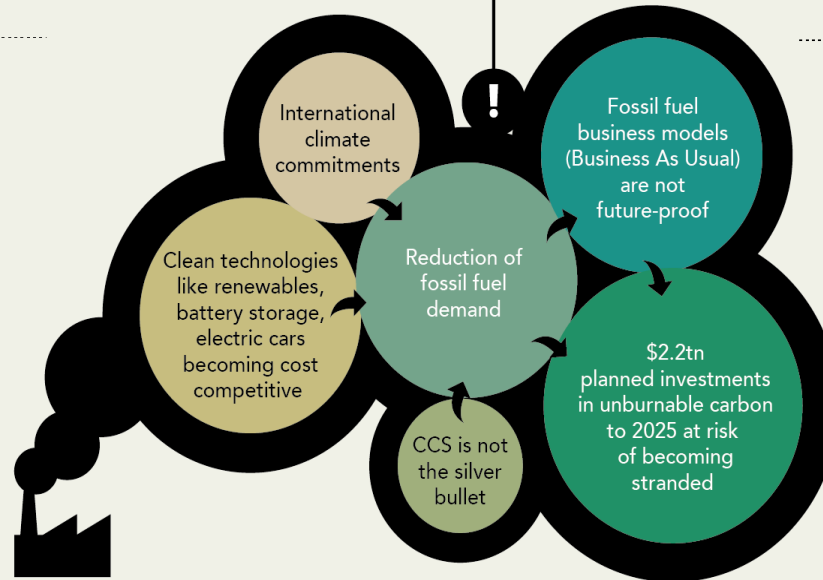
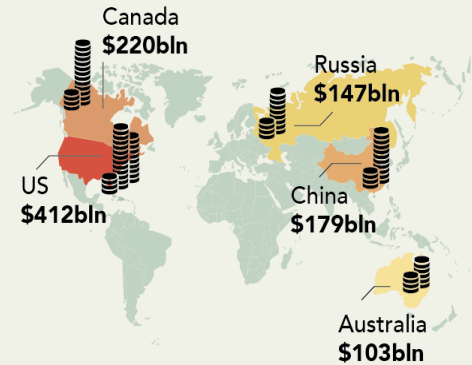
Top 3:

Shell → should each avoid potential investment of over **\$70bn**
 Exxon →
 Pemex →

Oil and gas majors' potential investment on projects that **won't be needed** in a 2°C scenario



Which are the countries with most financial exposure?



Do the 2°C stress-test



Institutional Investors
 Derisk portfolio by identifying companies aligned with a 2°C demand scenario or engaging with those that are not



Companies
 Provide information on the decisions taken to align corporate strategy with a 2°C demand scenario



Governments
 Stress test national resources, infrastructure and energy plans against a 2°C demand scenario



Analysts & Advisors
 Provide sensitivity analysis of which stocks are more resilient to a 2°C demand scenario

Sovereign risks too



- Oil and gas exporters (Russia, Algeria, Venezuela, Nigeria, Norway and Brazil) have been hit by crash in world oil price.
- Norway has managed by dipping in its huge SWF and managed to mitigate their depreciation of their currency.
- Nigeria and others have had huge depreciations, high budget deficits, loss of foreign reserves and inflation. Russia did less bad, since it did a big once and for all depreciation of the Ruble.
- Still, these countries suffer if they commit to Paris COP-21 as they have stranded carbon assets.
- Russian cannot burn 20% of oil and 60% of gas reserves in view of COP-21, so Russia's budgetary policies will be even more unsustainable and more tightening of fiscal stance is required - a further 1 %-point of GDP on top of what is needed to deal with sustained lower oil prices.
- So how much tightening of fiscal chance is required if there is risk of stranded assets due to unanticipated tightening of climate policy, drops in oil prices and rapid green technological progress.

Other threats to oil and gas producers



- Pricing carbon and subsidising renewables will put fossil fuel producers out of business.
- But also risk of oil and gas prices staying low for long time due to expansion of shale gas & unconventional oil.
- And arrival of new and cheap fossil fuel substitutes driven by technical progress (LNG, sub-surface platforms, sea bed extraction).
- Arrival of new game-changing carbon-free substitutes (e.g., fusion).
- Risks of new technology and tightening climate policy induces fossil fuel producers to pump more vigorously: Green Paradox.
- Might this incite fossil fuel importers to price carbon more quickly and vigorously (to capture some of scarcity rents). Vicious circle?

What can gas-rich countries do given these risks?



- Diversify and becomes less dependent on fossil fuel.
- Work on a plan B!
- Make product and labour markets more flexible. Get rid of monopolies and make markets transparent and more competitive.
- Improve institutions and invest in state capacity (i.e., power to tax, support contract and infrastructure, establish peace and order, and spend on collectively valuable goods and services) before fossil fuel has run out or has become uncompetitive.
- Get rid of fossil fuel subsidies.
- Save the windfalls for as long as they last in a SWF. This does not only smooth consumption, but also helps to smooth the real exchange rate.
- Diversify investments in the SWF away from oil (correlated with the market). Divest from fossil fuel funds. Deleverage as fossil fuel runs out.
- Hedge by investing in decarbonised stock market index.

SWFs account for US\$ 6.4 trillion in assets. Norway is largest single fund

Largest SWFs by country, total SWF assets (US\$ billion, 2014)



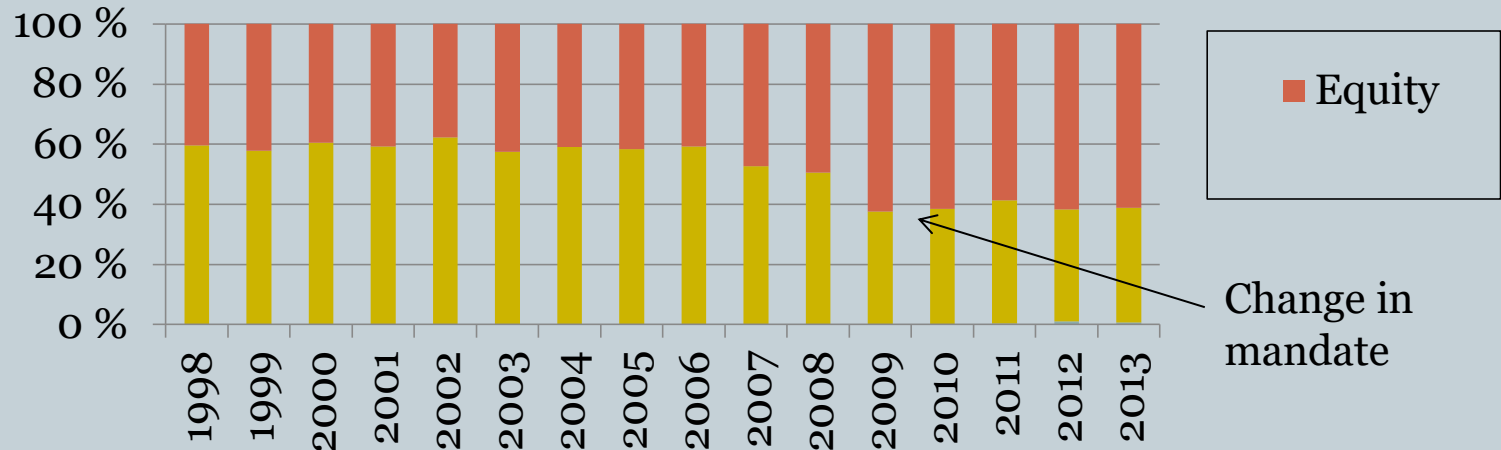
Source: Sovereign Wealth Fund Institute (2014)

Norway's fund is worth US\$ 840 billion

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The overall asset mix has been stable...

Norway Government Pension Fund Global, asset mix (%)



...and is set by mandate from the Ministry of Finance

Ministry of Finance Mandate:

<u>Asset</u>	<u>Sub-asset</u>	<u>Benchmark</u>
Equity: 60%		• FTSE Global All Cap index
Bonds: 40%	Government: 70%	• Barclays Global indices
	Corporate: 30%	

Managing below- and above-ground wealth



- *Intergenerational fund* to smooth welfare across generations even if windfall was deterministic but temporary. Take account of pension explosion too when deciding on how much to save.
- Is the 4% rule sustainable? Norges Bank Governor has argued for 3% of SWF. But PIH would suggest a fixed % of *total* of below- and above-ground wealth?
- *Liquidity fund* to act as precautionary savings buffer against remaining unhedged volatility of oil prices. Dip into it when oil prices are temporarily low.
- More generally, need to convert below-ground assets into above-ground assets (Hartwick rule).

Intuition of optimal saving rule



- “If in doubt, smooth it out”.
- Save marginal Hotelling oil rents using world price of oil and marginal extraction costs
- Save less/delay depletion if oil price is expected to rise in future and if improvements in oil extraction technology are expected in future
- Save less (more) and postpone (speed up) depletion if country is a net creditor (debtor) and expects future world interest rate to rise
- Borrow for temporary public spending increases (recession, war) and save for anticipated future spending hikes (pension bomb)

Effect of crash in commodity prices



- If drop in oil price is temporary, dip in the SWF or borrow on international capital markets to prevent drops in consumption.
- If drop in oil price is permanent, cut consumption and spending.
- Algeria, Nigeria and Brazil are experiencing big deficits, inflation, rapid loss of foreign reserves, and impending conflict as resource revenues drop.
- Depreciation of real exchange rate will shift factors out of oil and mining and into other traded sectors.

What assets should fund invest in?



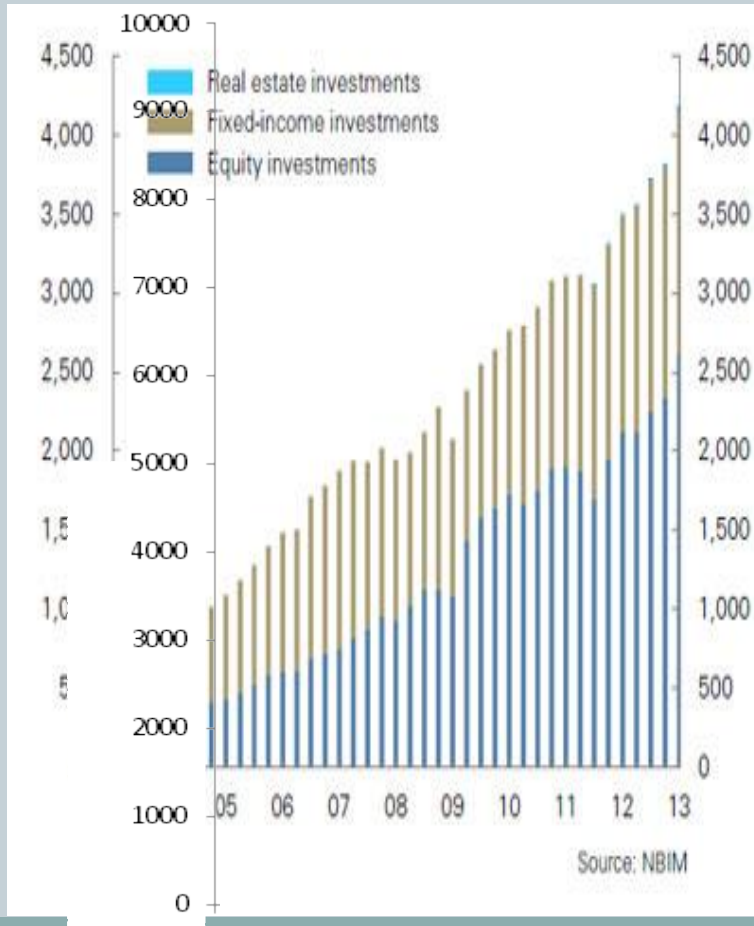
- Countries with net foreign assets should invest more in stocks whose fortunes are inversely related to those of the oil market: energy-intensive companies (aluminium smelters, steel producers, plastic manufacturing, etc.) and producers of renewables, energy-efficient cars in the short run, etc.
- Then one needs to hold less precautionary buffers
- But invest less in assets that are positively correlated with oil: oil and gas stocks.
- **Divest even without risk of tough climate policy and stranded assets!**



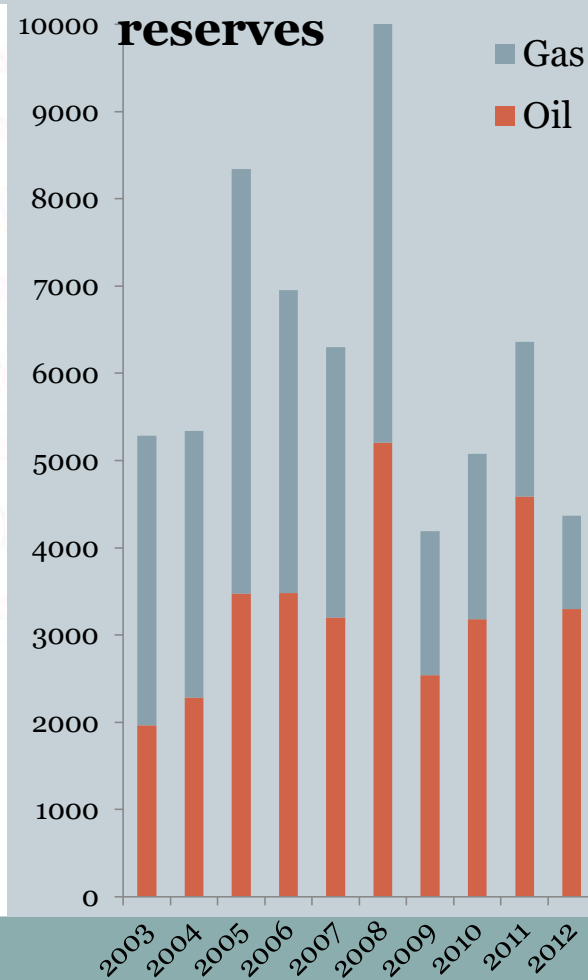
Norway has a large and volatile exposure to oil and gas prices in its subsoil reserves



Government Pension Fund Global

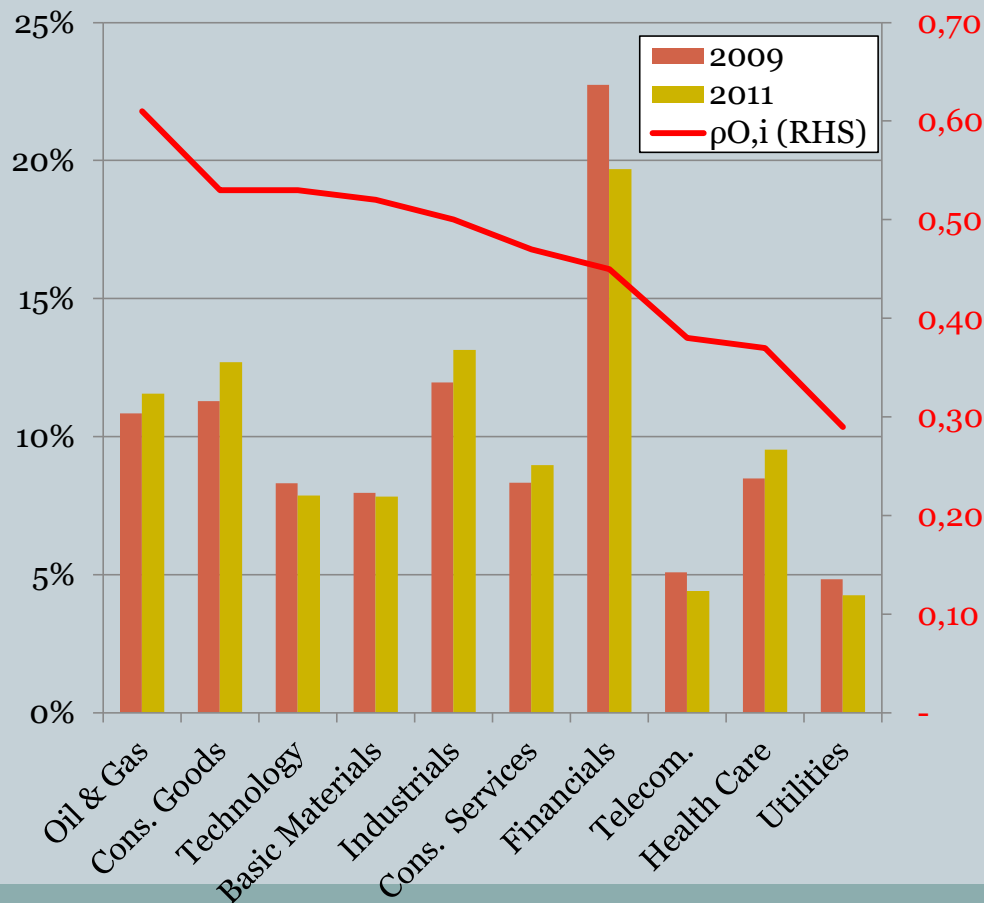


Proven subsoil reserves



Norway's portfolio allocation has been stable and seemed uncorrelated with oil prices. But note that oil prices and asset returns are positively correlated, which does not make for a diversified portfolio.

Norway GPFG equity allocation and correlation returns with oil price (%)



Out-of-date snapshot

Diversified:

- Holds equity in 7427 companies (2012)

Well-performing:

- Net returns:
 - 2013: 15.9%
 - Since 1998: 3.0%

CAPM-Merton-Hotelling model: portfolio allocation and subsoil oil



Have a fully diversified portfolio of risky assets independent of preferences, but mix of risky/safe assets depends on preferences.

Asset allocation

Portfolio Equation:

- Diversify: offset subsoil oil by taking longer (shorter) positions in all assets negatively (positively) correlated with oil
- Leverage up all risky asset holdings and **deleverage as oil runs out if necessary by going short in safe asset**

Consumption

Keynes-Ramsey rule:

- Consumption is a fixed proportion of below- and above-ground wealth (not just above-ground wealth!)
- Use precautionary savings to manage residual volatility of the total portfolio, and the unhedgable component of oil

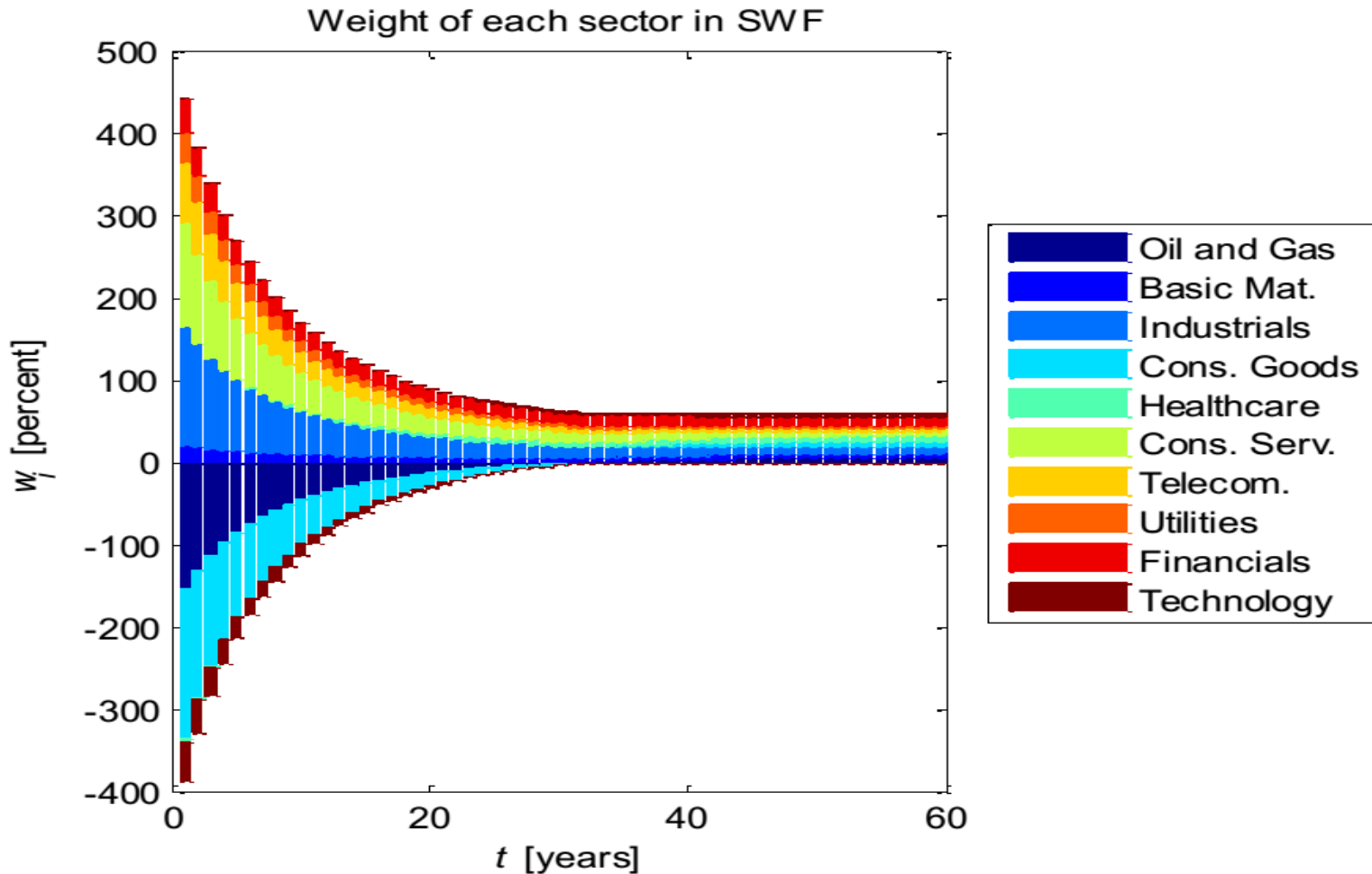
Extraction

Hotelling Equation:

- uncertainty speeds up optimal oil extraction rate

Portfolio shares: large *short* positions in oil sectors, which are undone as oil is depleted

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Theory: Oil and portfolio management



- Oil price is positively correlated with share prices, so short oil & gas and technologies, and go long in utilities, financials and consumer services.
- Invest more in stocks that are negatively correlated with oil price: where oil is an input (plastics, transport, consumer goods) which are a substitute for oil (renewables).
- Allowing for risk of decarbonisation of global economy suggests to short oil even more and to invest more in renewable energy stocks.

Practice: Oil and portfolio management



- However, these theoretical prescriptions ignore practical constraints to do with political problems of shorting stocks and shares, high transaction costs of continuously adjusting portfolio, and other elements of national assets and liabilities.
- So portfolio management will be different from the Merton-Hotelling prescriptions. It will be second best.
- If second-best management is restricted to adjusting only the equity/bond mix and the spending rule, we find that the equity weight should *rise* from 45 to 60% of total below- and above-ground wealth as oil is extracted (rather be a fixed 60% of above-ground wealth). The rise in the equity weight reflects falling exposure to oil as oil is depleted, since the oil price is positively correlated with the FTSE All Cap Index. This second-best policy also hedges subsoil risk.
- Other second-best portfolio management strategies should be looked at.

FUTURE CHALLENGES



- Divesting fossil fuel or better dynamic and transparent hedging strategies against the risk of a dramatic and prolonged fall in oil prices, the “risk” that cumulative emissions will really be curbed, and the “risk” of rapid technological progress in renewable energies is a good start.
- Many oil-rich countries that do not have SWFs or a plan B are in dire situation, and many have suffered from the curse of natural resources.
- But oil-rich countries with a SWF need to think of de-carbonisation strategies taking account of their large stocks of below-ground oil and gas reserves.

Thank you for your attention