Virtual Seminar on Climate Economics

Federal Reserve Bank of San Francisco

Organizing Committee:

Glenn Rudebusch (Federal Reserve Bank of San Francisco)
Michael Bauer (University of Hamburg)
Stephie Fried (Federal Reserve Bank of San Francisco)
Òscar Jordà (Federal Reserve Bank of San Francisco)
Toan Phan (Federal Reserve Bank of Richmond)

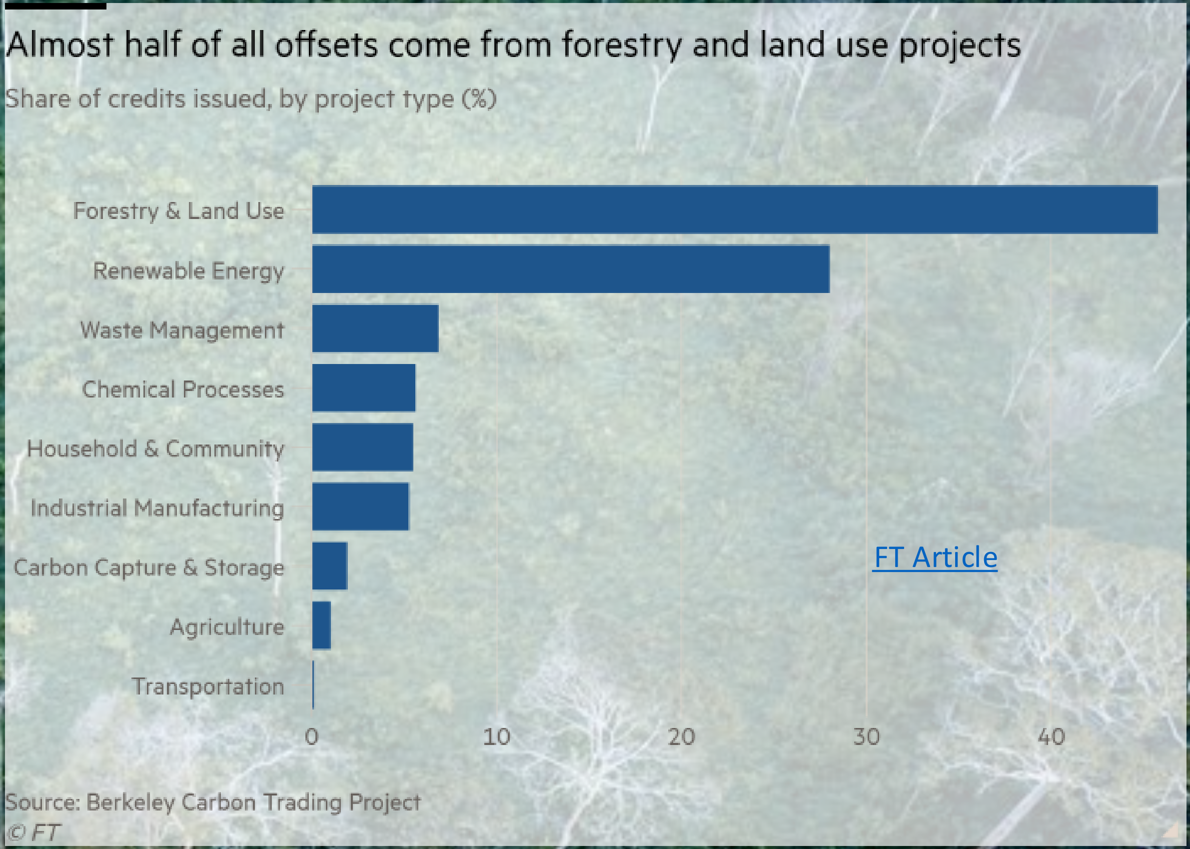
Photo Credit

The social value of offsets

Ben Groom (Exeter/LEEP and LSE/Grantham Research Institute) and Frank Venmans (LSE/GRI)

The Offset Market

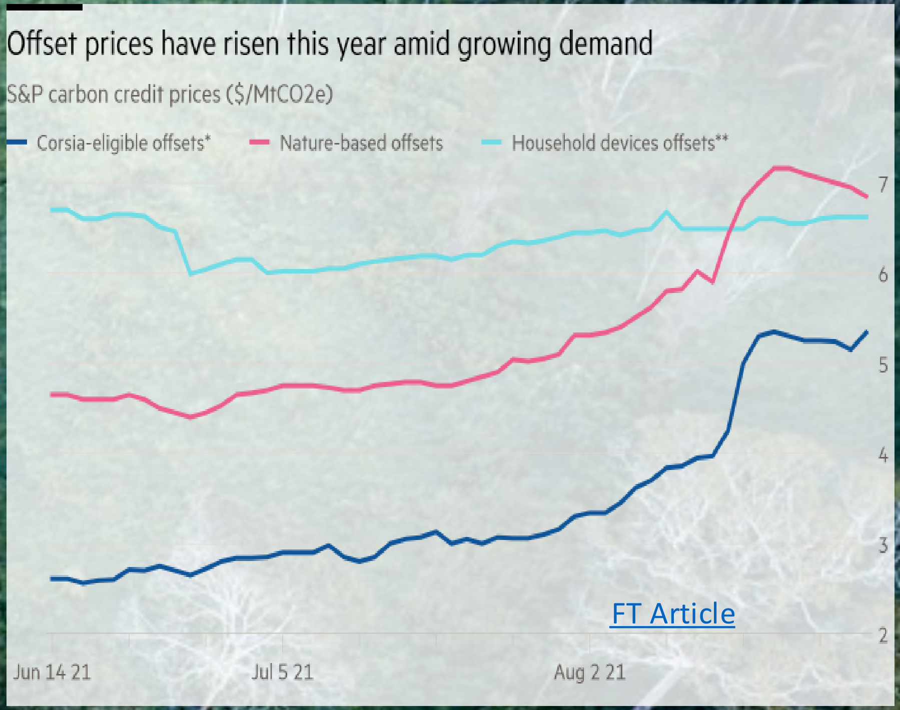
- Renewable energy
- Energy efficiency
- Forestry: avoided deforestation or reforestation
- Transport
- Agriculture
- Methane capture
- Household (e.g. cook stoves)
- https://www.pureleapfrog.org/ba/carbon_neutral-faqs/



FT Article

The Offset Market

- Net-Zero + NDCs: COP26, UK, EU, India, etc.;
- GFANZ: $130tn assets net zero by 2050;
- Shell, BP, claim net-zero using offsets;
- 2017 – 2019: $750m carbon offsets traded (FT);
- Evidence:
  - ProPublica: Only 50% success rate in Acre, Brazil;
  - Calel et al. (2021) CDM: 40% of projects are additional, none are 100% individually.
  - 37% of forest projects overlapped with PAs (REDD+);



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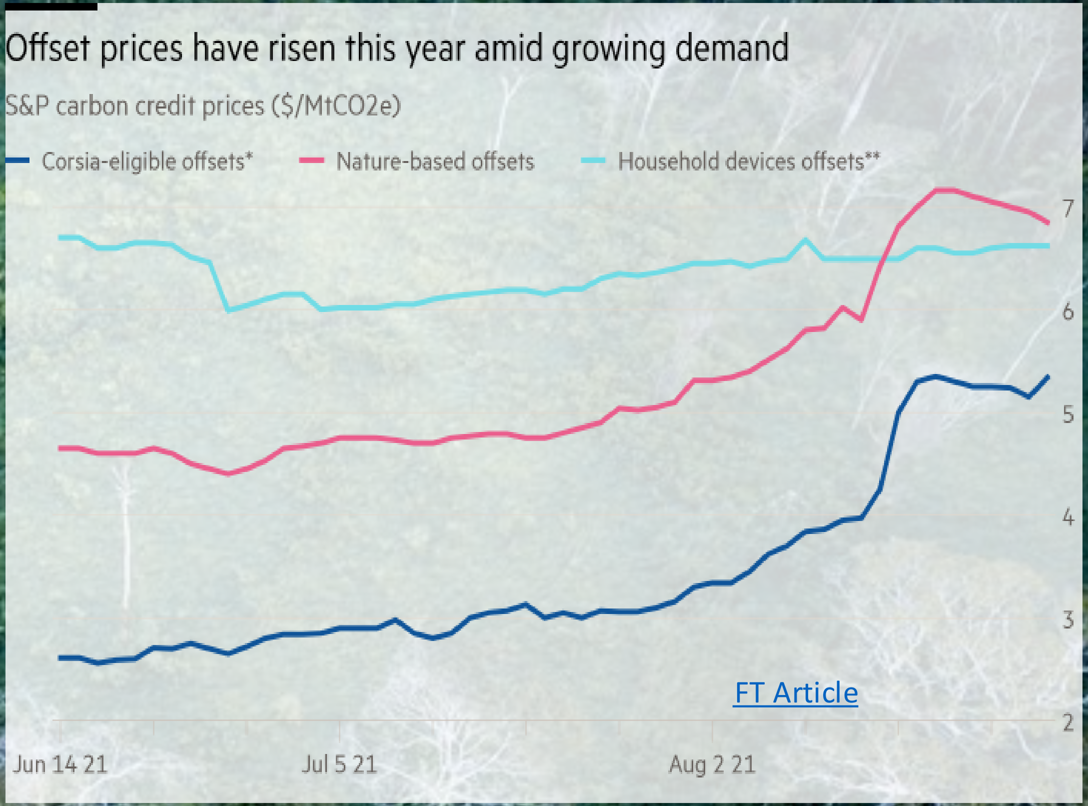
The Offset Market: perceptions

- “guilty until proven innocent”
- “scaling up could be dangerous”
- “surplus of bad offsets”
- “no trust in the current system”
- Science Based Targets: No offsets!
- Financial institutions, ETS schemes: no credits.

But:

- “perfect is the enemy of the good”
- “improved governance required”
  - Improvements
- Stand. Chart. + Mark Carney Task Force
- “standardise contracts….. trust and fungibility of the carbon offset market”

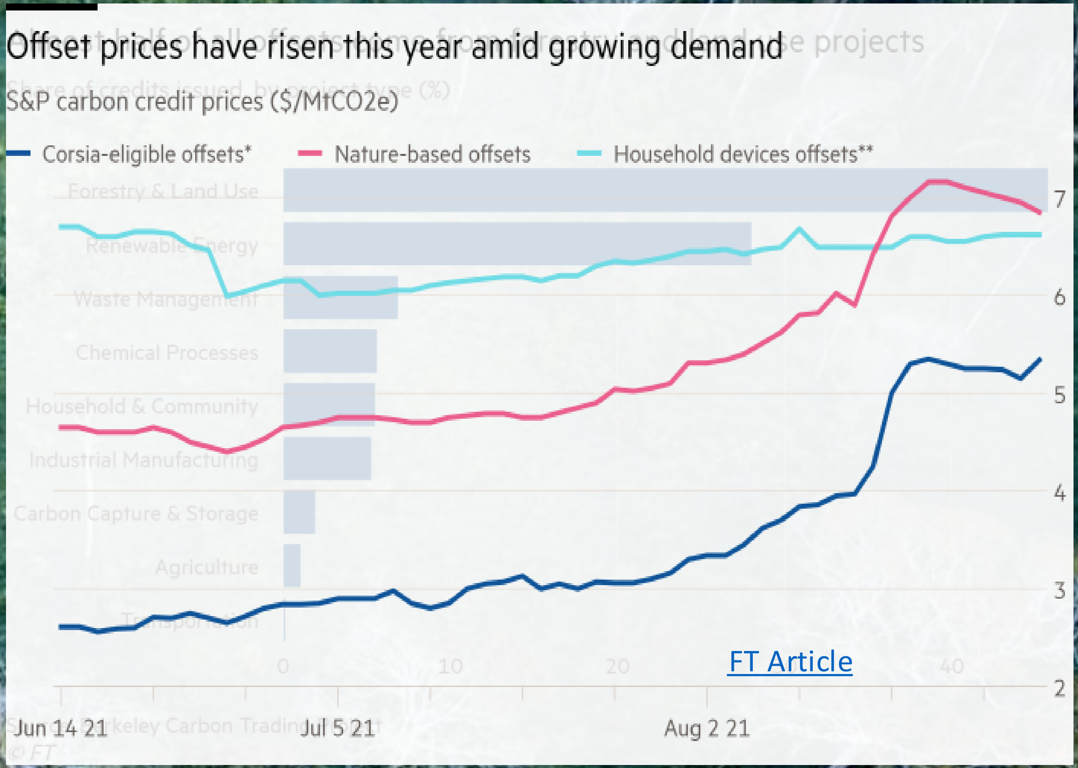


Research question

- Clear problems and risk with offsets:
  - Impermanence
  - Risk of failure
  - Additionality

- What is the social value of offsets?
  - How ought they to be “priced”
  - Should they be a part of the net-zero strategy?

- Nature-Based Solutions
  - Biodiversity is also important
  - (Dasgupta Review 2021, Kunming COP15: 30 by 30)



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In a nutshell

- We show:
- The social value of an offset (SVO) formula

$$SVO^{\phi,\tilde{\varphi}}_{\tau_1,\tau_2} = SCC_0 \underbrace{e^{(x-r)\tau_1}}_{delay\ until\ \tau_1} \underbrace{\left(1 - e^{(x-r)v}\right)}_{Impermanence} \left[\underbrace{\frac{(r-x)}{r+\phi-x}}_{failure\ risk} - \underbrace{\frac{(r-x)}{r-x+\phi+\tilde{\varphi}}}_{additionality\ risk} \right]$$

- Number of risky offsets that compensate 1 tonne of CO2 emissions?
- Calibrate to analytical climate models and RPCs
- Result: SVO is more than zero and less than the social cost of carbon

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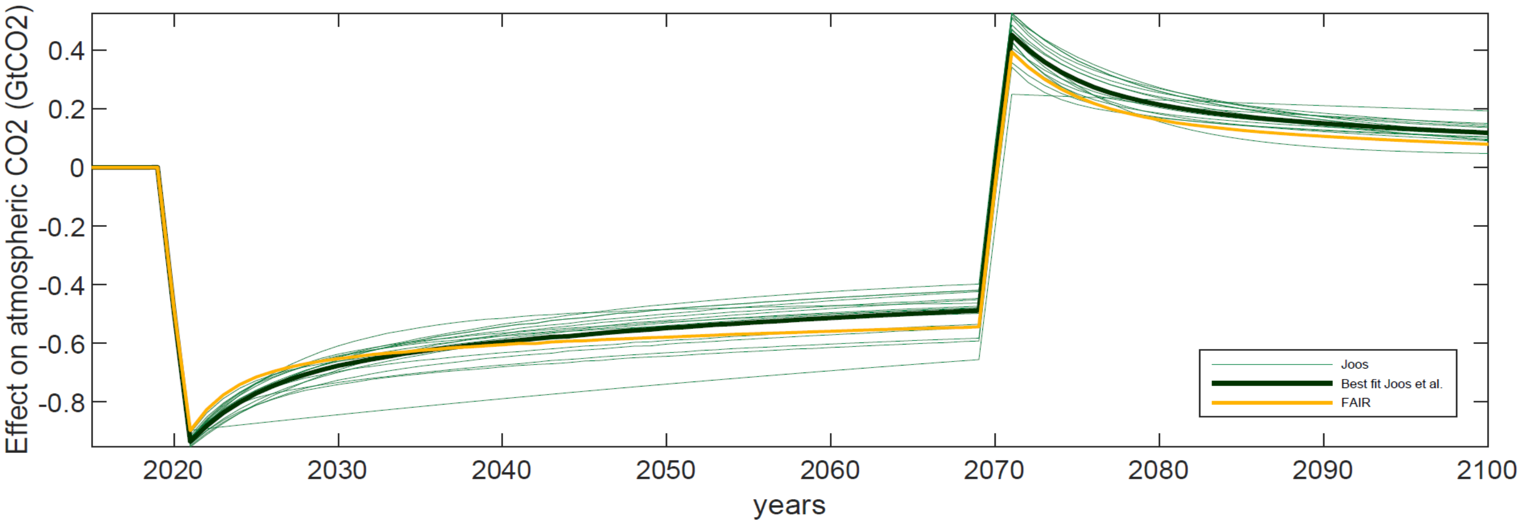
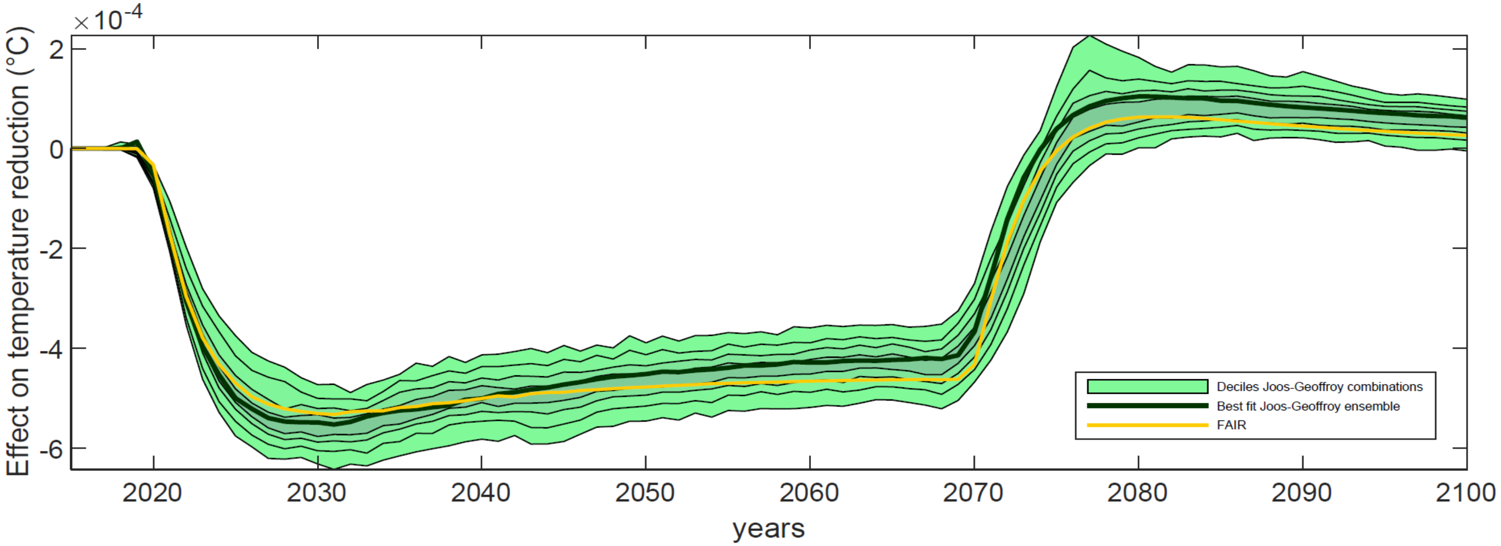
Climate dynamics: a temporary reduction



(Joos et al, 2013; Geoffroy et al 2013, CIMP5 ensemble)

Temperature:

$$T_t = \underbrace{\zeta}_{TCRE} \quad \underbrace{S_{t - \underbrace{\xi}_{delay}}}_{Cum\ Emission}$$



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Social Cost of Carbon (SCC)

- Social cost of carbon is the discounted sum of marginal damages

$$SCC_\tau = \int_{t=\tau+\xi}^{\infty} e^{-r(t-t_0)} \zeta \underbrace{D_T}_{marg\ damage} dt$$

- Values a permanent removal of CO2 emissions

A temporary offset

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A temporary offset

- Project absorbs emission from moment τ_1 to τ_2 (define $v = \tau_2 - \tau_1$)

$$SVO_{\tau_1 \tau_2} = \int_{t=\tau_1+\xi}^{\tau_2+\xi} e^{-r(t-t_0)} \zeta \underbrace{D_T}_{marg\ damage} dt$$

- This is the difference between present values of the SCC_{τ_1} and SCC_{τ_2}

$$SVO_{\tau_1 \tau_2} = e^{-r(\tau_1 - t_0)} SCC_{\tau_1} - e^{-r(\tau_2 - t_0)} SCC_{\tau_2}$$

- “Correction factor” compared to SCC (eternal riskless project), if *x* is the growth rate of the SCC:

$$SVO_{\tau_1,\tau_2} = SCC_0 \underbrace{e^{(x-r)\tau_1}}_{delay\ until\ \tau_1} \underbrace{\left(1 - e^{(x-r)(\tau_2 - \tau_1)}\right)}_{Impermanence}$$

A temporary offset with failure risk

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A temporary offset with failure risk

- Constant probability ϕ that the project fails;
- Probability of project surviving longer than τ years is $P(t \geq \tau) = e^{-\phi\tau}$
- The risk has a similar effect as the discount rate

$$SVO^{\phi}_{\tau_1,\tau_2} = \int_{t=\tau_1+\xi}^{\tau_2+\xi} e^{-(r+\phi)(t-\tau_1)} \zeta \underbrace{D_T}_{marg\ damage} dt$$

- "Correction factor":

$$SVO^{\phi}_{\tau_1,\tau_2} = SCC_0 \underbrace{e^{(x-r)\tau_1}}_{delay\ until\ \tau_1} \underbrace{\left(1-e^{(x-r)(\tau_2-\tau_1)}\right)}_{Impermanence} \underbrace{\frac{(r-x)}{r+\phi-x}}_{failure\ risk}$$

A temporary offset with failure and additionality risk

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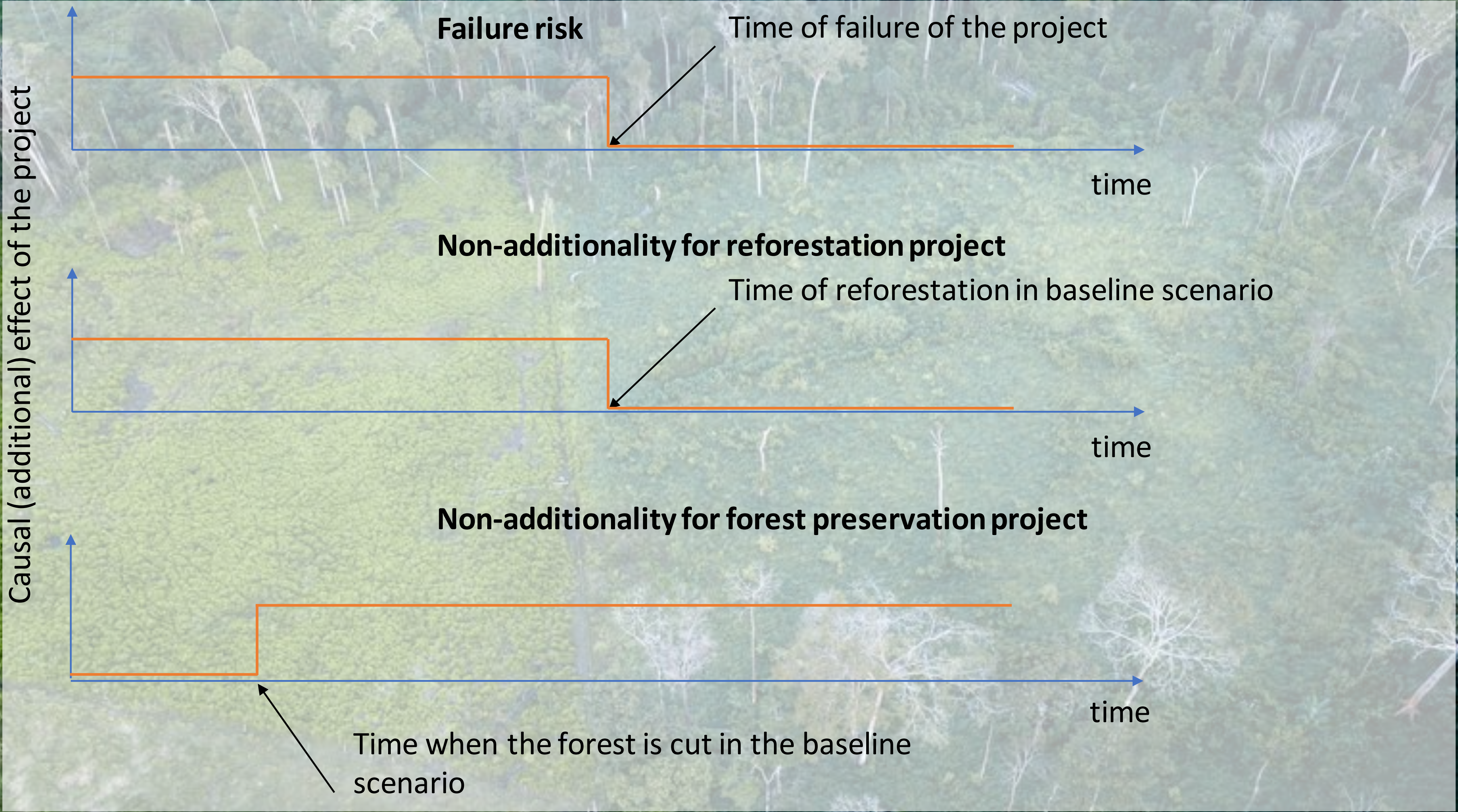
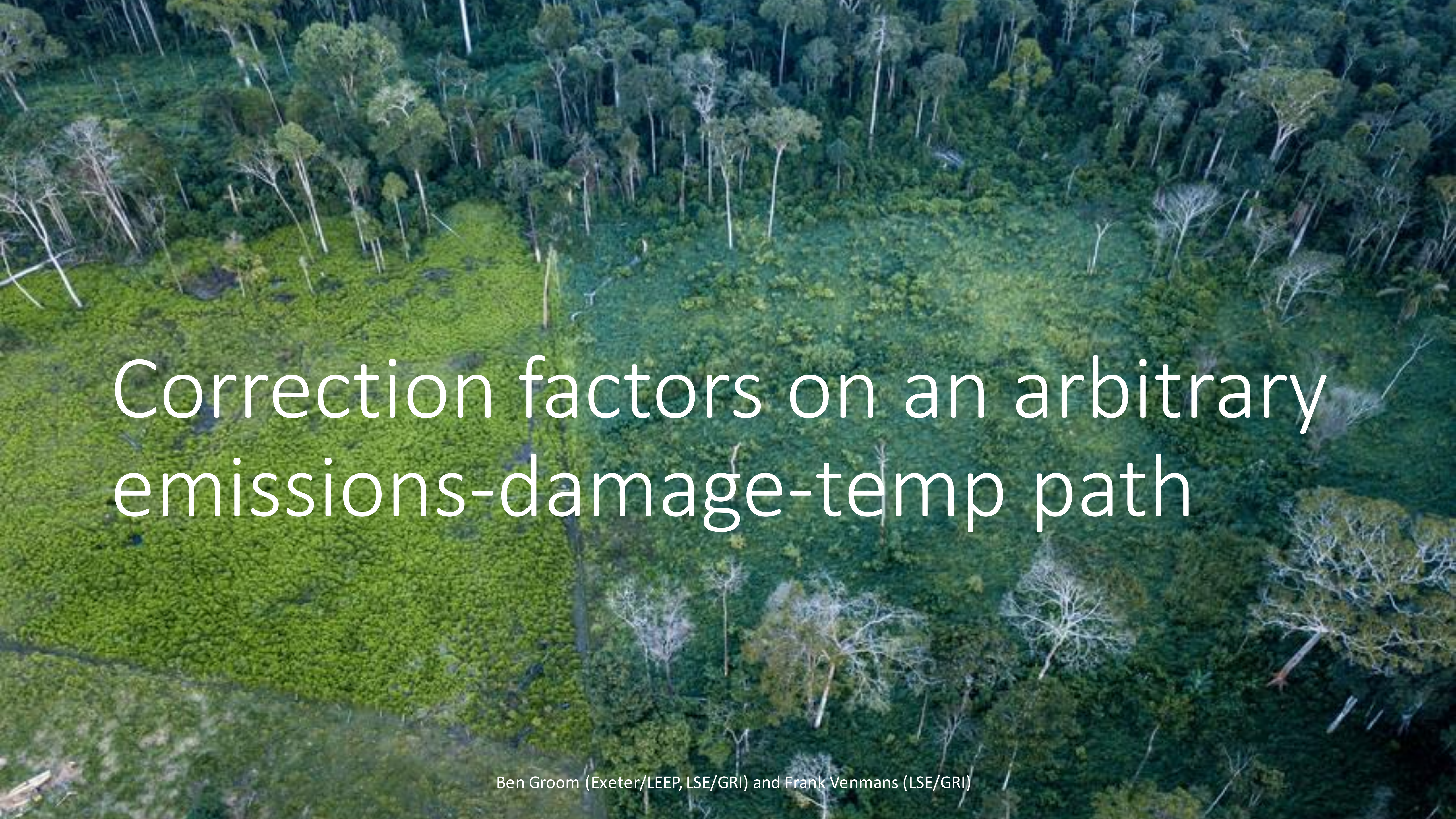
Additionality risk



Additionality risk

- **Reforestation project**: constant probability φ of non-additionality (reforestation in the baseline) ➔ add up ϕ *and* φ;
- **Conservation project**: constant probability $\tilde{\varphi}$ in the baseline that the forest would have disappeared (and the project becomes additional);
- Likelihood of additionality from τ onwards $P(t \leq \tau) = 1 - e^{-\tilde{\varphi}\tau}$;
- "Correction factor":

$$SVO^{\phi,\tilde{\varphi}}_{\tau_1,\tau_2} = SCC_0 \underbrace{e^{(x-r)\tau_1}}_{delay\ until\ \tau_1} \underbrace{\left(1 - e^{(x-r)(\tau_2-\tau_1)}\right)}_{Impermanence} \left[\underbrace{\frac{(r-x)}{r+\phi-x}}_{failure\ risk} - \underbrace{\frac{(r-x)}{r-x+\phi+\tilde{\varphi}}}_{additionality\ risk}\right]$$



Correction factors on an arbitrary emissions-damage-temp path

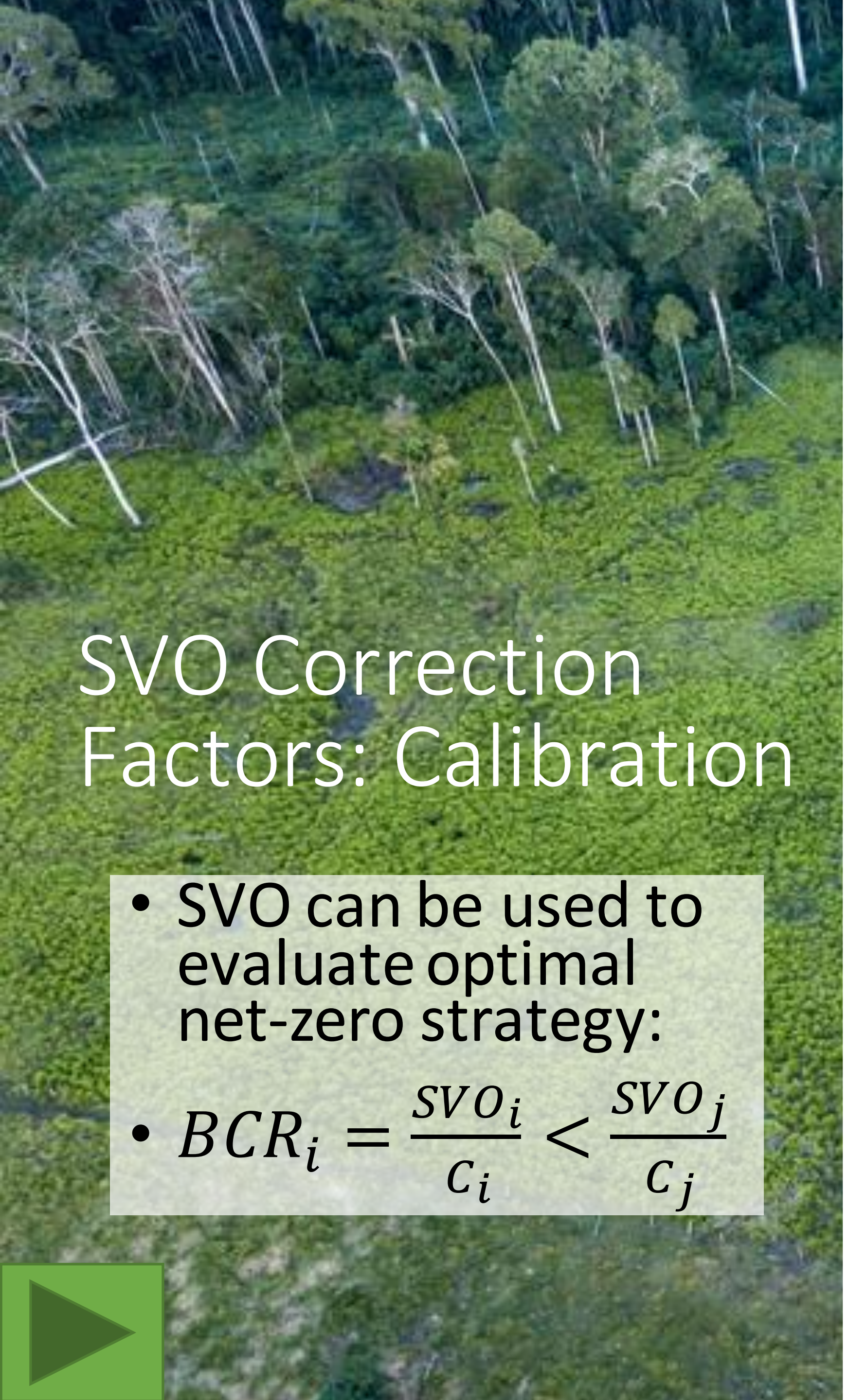
Ben Groom (Exeter/LEEP, LSE/GRI) and Frank Venmans (LSE/GRI)

Correction factors on arbitrary path

- Assume damage is quadratic so……
- Marginal damage: $Y_T = -Y\gamma T$;
- Simple, flexible integral form for the SVO correction factor:

$$\frac{SVO}{SCC} = \frac{e^{-r\tau_1} \int_{\tau_1+\xi}^{\tau_2+\xi} e^{-(r+\phi+\varphi)(t-\tau_1)} \zeta\gamma Y_t T_t dt}{\int_{t=\xi}^{\infty} e^{-rt} \zeta\gamma Y_t T_t dt}$$

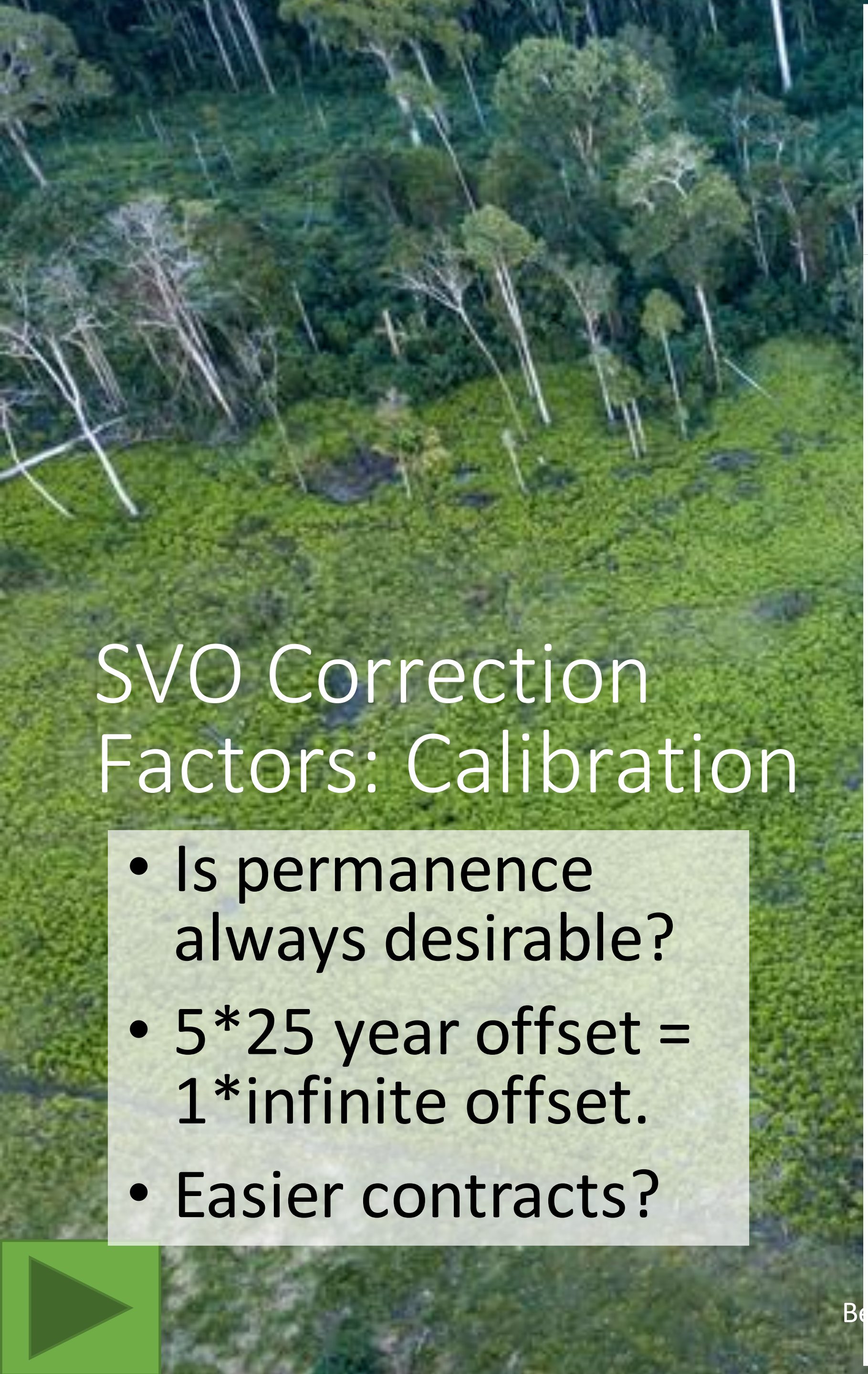
- Both the damage factor and the TCRE cancel out!
- Could allow for projects that gradually absorb/emit carbon over time.



SVO Correction Factors: Calibration

- SVO can be used to evaluate optimal net-zero strategy:
- $BCR_i = \frac{SVO_i}{C_i} < \frac{SVO_j}{C_j}$

IPCC Scenario (Temp in 2100)	Risk at start $\tilde{\varphi}$	Risk at end $\phi + \varphi$	SVO Correction factors (max.duration, v) 25	50	100	∞	SCC ($\$/tCO_2$) Damages ($\gamma$) γ=0.0077 Howard and Sterner, 2017	γ=0.0025 Nordhaus, 2017
RCP 2.6 (1.8°C)	1000	0	24%	44%	70%	100%	109	35
		0.25	23%	42%	63%	83%	109	35
		0.5	23%	40%	58%	71%	109	35
	0.5	0	23%	43%	69%	99%	109	35
		0.25	22%	40%	62%	82%	109	35
		0.5	21%	38%	56%	69%	109	35
	0.25	0	21%	41%	67%	97%	109	35
		0.25	20%	39%	60%	80%	109	35
		0.5	20%	36%	54%	68%	109	35
RCP 3.4 (2.6°)	1000	0	19%	37%	66%	100%	142	46
		0.25	19%	35%	59%	81%	142	46
		0.5	18%	33%	53%	68%	142	46
	0.5	0	18%	36%	65%	99%	142	46
		0.25	18%	34%	58%	80%	142	46
		0.5	17%	32%	52%	67%	142	46
	0.25	0	17%	35%	63%	97%	142	46
		0.25	16%	33%	56%	79%	142	46
		0.5	16%	31%	51%	66%	142	46



SVO Correction Factors: Calibration

- Is permanence always desirable?
- 5*25 year offset = 1*infinite offset.
- Easier contracts?

IPCC Scenario	Risk at start	Risk at end	SVO Correction factors (max.duration, v)				SCC ($\$/tCO_2$) Damages ($\gamma$)	
(Temp in 2100)	$\tilde{\varphi}$	$\phi + \varphi$	25	50	100	∞	γ=0.0077	γ=0.0025
RCP 6.0 (3.1°C)	1000	0	17%	34%	64%	100%	161	52
		0.25	17%	32%	57%	81%	161	52
		0.5	16%	31%	51%	67%	161	52
	0.5	0	16%	33%	63%	99%	161	52
		0.25	16%	31%	56%	80%	161	52
		0.5	15%	30%	50%	66%	161	52
	0.25	0	15%	32%	61%	98%	161	52
		0.25	14%	30%	55%	78%	161	52
		0.5	14%	28%	49%	65%	161	52
RCP 8.5 (5.1°C)	1000	0	13%	29%	60%	100%	233	76
		0.25	13%	27%	53%	79%	233	76
		0.5	12%	25%	47%	64%	233	76
	0.5	0	12%	28%	59%	99%	233	76
		0.25	12%	26%	52%	78%	233	76
		0.5	12%	24%	46%	64%	233	76
	0.25	0	11%	27%	58%	98%	233	76
		0.25	11%	25%	51%	77%	233	76
		0.5	11%	24%	45%	63%	233	76

Be

Cost Effectiveness Framing

Ben Groom (Exeter/LEEP, LSE/GRI) and Frank Venmans (LSE/GRI)

Two 'Carbon Equivalent' Projects:

- i) A permanent project;
- ii) Portfolio of a temporary and a permanent project;
- Portfolio preferred if:

$$C_{\tau_1,\infty} > C_{\tau_1,\tau_2} + e^{-r(\tau_2-\tau_1)} C_{\tau_2,\infty}$$

- Defining x as the mean rate of increase in the cost of projects:

$$C_{\tau_1,\tau_2} < \left(1 - e^{(x-r)(\tau_2-\tau_1)}\right) C_{\tau_1,\infty}$$

- If x is the efficient growth (of SCC) we obtain our previous result ($x < r$);
- Under Cost Effectiveness: $x = r$ (Hotellings Rule);
  - Temporary projects are worthless: ignore the delay value;
  - Non-welfare maximizing x will give non-welfare maximizing decision rule.

Conclusion

- Offsets: impermanent, risky and potentially non-additional: **still have social value (SVO) due to delay** (between zero and the SCC);
- Nature based solutions: although often uncertain, are not valueless;
- The BCR of NBS can be competitive compared to other offset *technologies;*
- CEA does not value the benefits of delay; CBA better (using SVO)
- Policy and governance:
  - Carney Task Force: contracting should take into account SVO;
  - Offset risk-ratings;
  - Disclosure by providers;
  - Comparisons can be done using our value-based correction factor
  - Extensions to systematic risks

Ben Groom (Exeter/LEEP, LSE/GRI) and Frank Venmans (LSE/GRI)

Photo Credit

Thanks!

Ben Groom (Exeter/LEEP and LSE/Grantham Research Institute) and Frank Venmans (LSE/GRI)

University of Exeter | Land, Environment, Economics and Policy Institute

LSE The London School of Economics and Political Science

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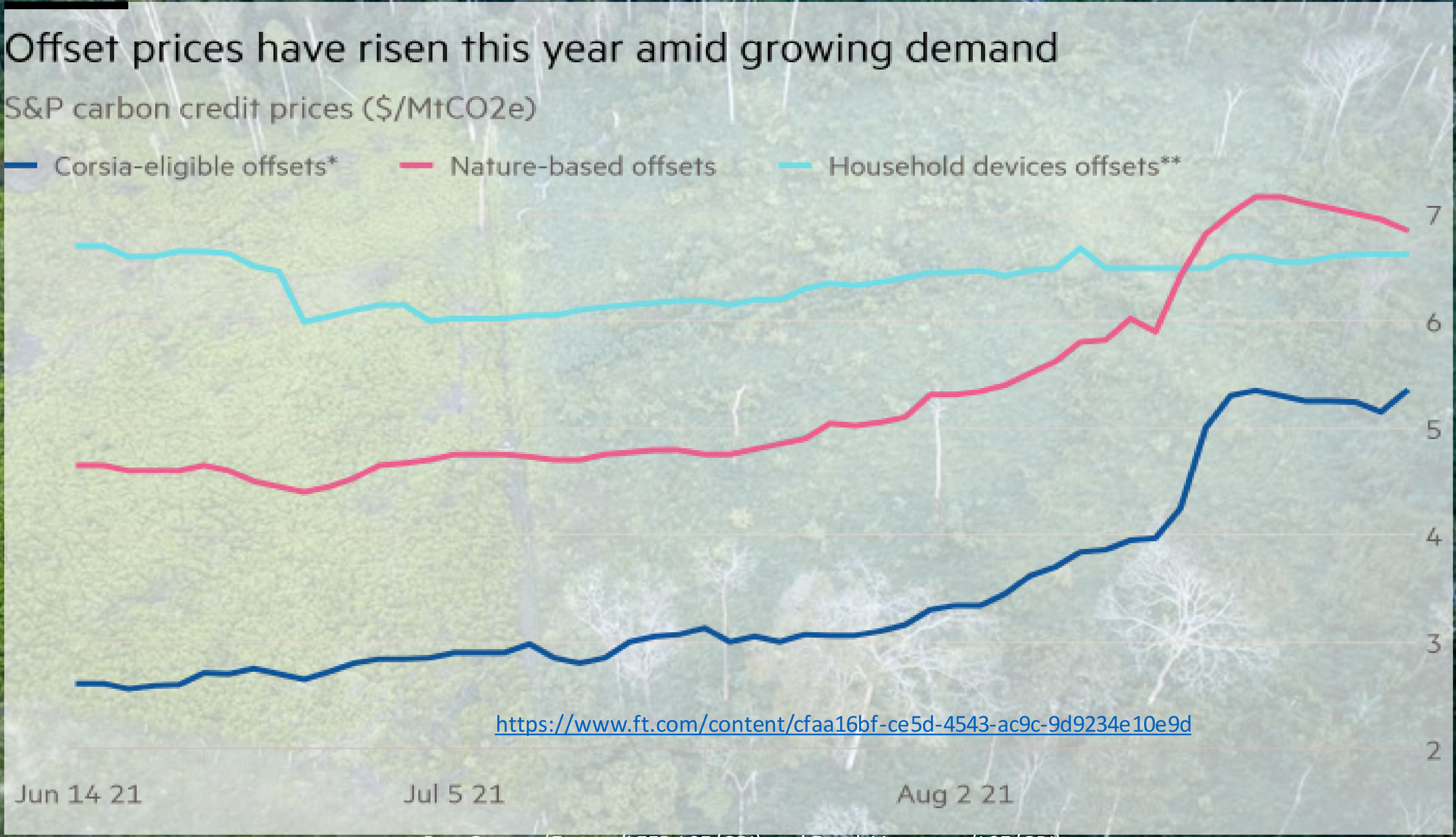
Additional Slides

Offsets and Net-zero



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Calibration

Table 1: Adjustment factors for non-permanence and risk. We assume a quadratic damages proportional to GDP $exp\left(-\frac{\gamma}{2}T^2\right)$ with damage parameters of Howard and Sterner (2017) (Column 8) as well as Nordhaus (2017) (Column 9). Temperature pathways evolve according to SSP1-RCP2.6; SSP4-RCP3.4; SSP4-RCP6.0 and SSP5-RCP8.5 (Riahi et al. 2017, www.https://tntcat.iiasa.ac.at). Other parameters are $r = 3.2\%; \tau_1 = 3year; \zeta = 0.0006°C/GtCO_2; GDPgrowth = 2\%; T_0 = 1.2°C$. We use equation 9 . For $\tilde{\varphi} = [0.5\ 0.25]$ the likelihood that the project is additional after 5 years is 92% and 71% respectively. For $\varphi + \phi = [0.0025\ 0.005]$ the likelihood that the project is additional after 50 years is 78% and 88% respectively.