Economics of Forest Carbon Offsets and Carbon Emissions Trading

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What about carbon offsets?

Mostly used in conjunction with Voluntary Emission Offsets, Clean Development Mechanism, Joint Implementation and Forestry Activities

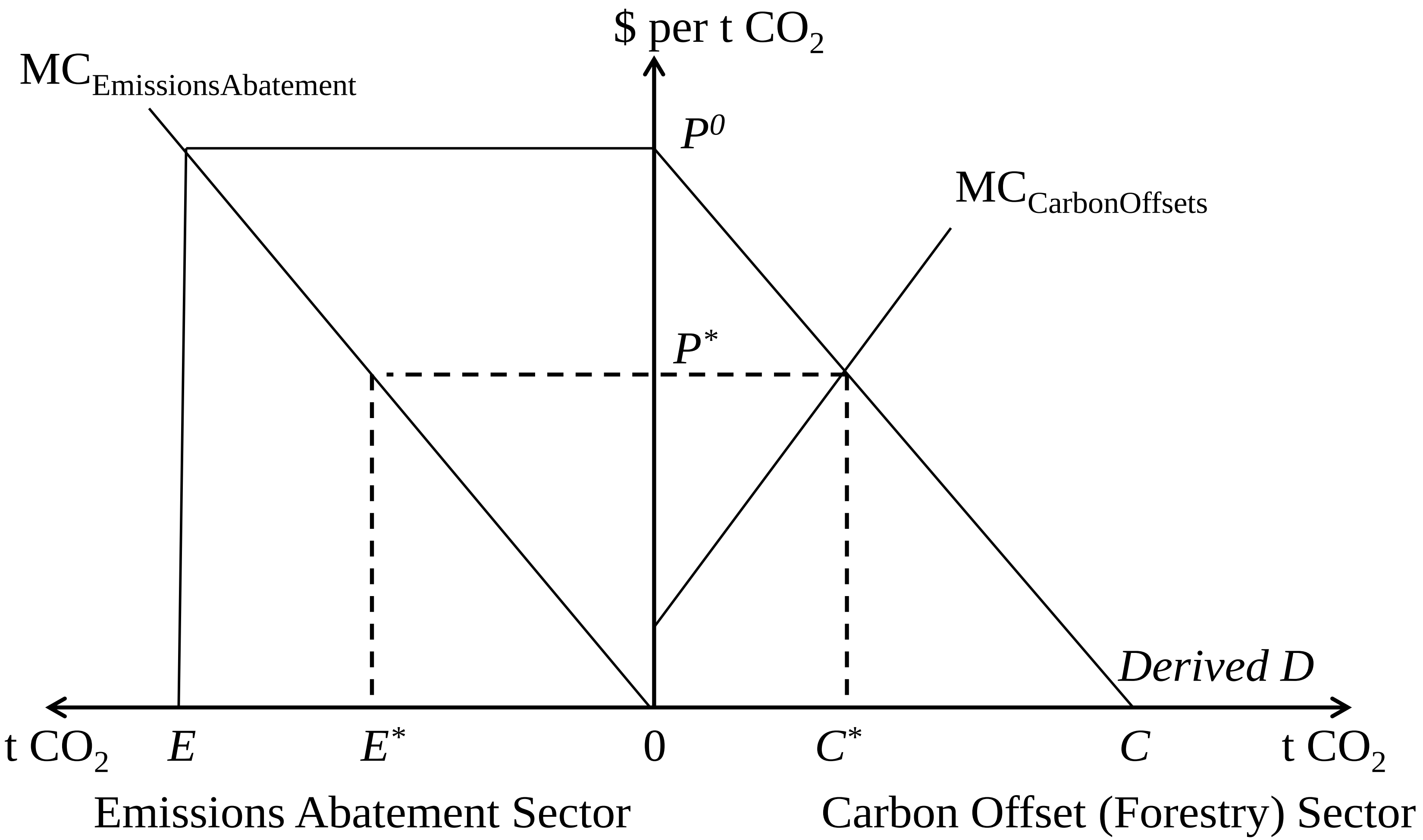
Introduction

- Types of carbon markets
  - Emissions trading with cap on emissions
  - Emissions trading with cap on emissions but with carbon offsets (EU-ETS)
  - Carbon offset trading with no cap
    - Government sponsored (Pacific Carbon Trust)
    - Voluntary markets
- How do carbon offset markets function? Well … There is only one rule: Follow the money!
- Governance is the main obstacle to cap-and-trade, and to the establishment of carbon offsets in forestry

Consider the UN FCCC process: Kyoto and Paris

- Kyoto Protocol permitted afforestation and reforestation to attain emission reduction targets as an intermediary step, which appears to have become semi-permanent. This carries over into Paris.
- As a result of the COP7 in 2001 at Marrakech, Morocco, forestry activities that remove CO_2 from the atmosphere to offset CO_2 emissions were promoted, but the deal gave credence also to preventing deforestation in developing countries – led to the term ARD.
- Current discussions have expanded 'preventing deforestation' to REDD and REDD+ – Reduced Emissions from Deforestation and forest Degradation with + denoting the benefits of protecting biodiversity (thereby linking the FCCC with the only other agreement signed at the 1992 Earth Summit Rio de Janeiro, the Convention on Biodiversity).
- REDD+ ideas have carried over from developing to developed countries: Pacific Carbon Trust purchases and resells credits from not harvesting forests, as does the Voluntary Carbon Exchange.
- How do carbon offsets work? At least in a mandatory market such as EU-ETS?

Compliance Markets and Effect of Forest Carbon Offsets



- Economists prefer tax on carbon emissions and subsidy for carbon removal (but see outcome of the Copenhagen Consensus 2010)
- Carbon offsets create all kinds of problems that we really cannot properly address
- Problems especially pertain to transaction costs, governance and the principal-agent (PA) problem.

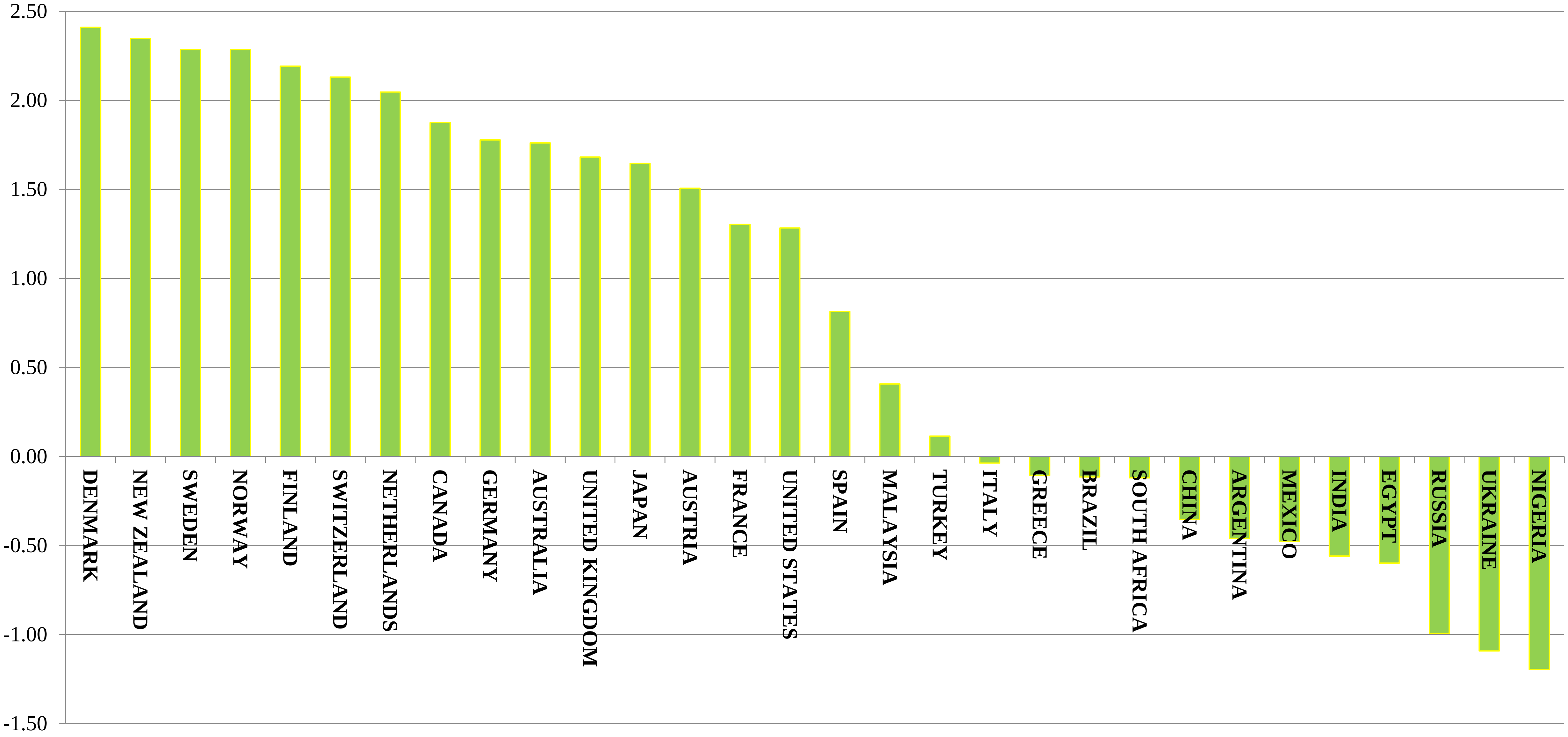
International climate accords and forestry activities for mitigating climate change resulted in various problems (some well known):

1. Additionality
2. Leakage
   - Micro: farmer plants trees on one field, clears trees on another
   - Macro: farmers in one region plant trees, price of land in agriculture rises, and landowners elsewhere convert forestland to agriculture
3. Double dipping:
   - Landowner receives payment for biodiversity, plus carbon credits
   - Afforestation in China: one country claims CERs under CDM, China claims a reduction in its emissions
4. Plethora of instruments
5. Transaction costs and governance

What happens when forest carbon offsets are included in an emissions trading scheme? Problems

- Transaction costs
  - Measurement
  - Monitoring
  - Costs of contracting (e.g., legal costs)
  - Accounting procedures
- Asymmetry of knowledge: Principal-agent problem (discussed below)
- Governance
  - Quality of institutions
  - Rule of law
  - Corruption (e.g., oversupply of credits)
    - Problem of corruption is shown on next slide. The countries of North America and northern Europe assume too much

- Overarching problem: CO_2 emissions trade for too low a price ➔ don't achieve desired reductions in CO_2



Control of Corruption Index, Selected Countries, World Bank, 2013
Scale: Very Good =+2.5 to Very Bad = -2.5]

In addition to corruption, problems of governance include:

- High transaction costs
- Uncertainty
- Additionality
- High potential for leakage
- Incompatible times horizons between forestry projects (something I refer to as the duration problem)
  - This makes it impossible to compare carbon offset credits from one forestry project to another
  - Forest-derived carbon offsets cannot be compared to emission reductions (witness the machinations regarding long-term and short-term offsets)

Clean Development Mechanism

- Took a long time to certify the first forestry project
- Between November 2007 and 2016, only 70 afforestation/ reforestation projects certified
  - average life span 22 years
  - only 0.8% of registered projects
  - 117 projects created that use wood pellets or forest biomass, with life span of only 8 years.

Type of Forestry Project	Number
Afforestation	11
Mangroves	1
Agroforestry	4
Reforestation	54

CDM projects as of April 1, 2016

Type	number		Expected CERs/yr ('000s)		CERs Issued ('000s)	
Wind	2605	31%	238,093	20%	179,859	11%
Hydro	2228	26%	329,260	27%	219,217	13%
Biomass energy	750	9%	51,240	4.3%	49,977	3.0%
Methane avoidance	690	8%	29,174	2.4%	28,171	1.7%
Solar	430	5.1%	13,773	1.1%	3,093	0.19%
Landfill gas	403	5%	58,136	5%	76,092	5%
EE own generation	383	4%	50,431	4%	74,160	4.5%
Fossil fuel switch	133	1.6%	69,499	6%	56,882	3.4%
EE Industry	129	1.5%	4,638	0%	3,582	0.2%
Coal bed/mine methane	111	1.3%	72,975	6%	45,278	2.7%
EE Supply side (power plants)	105	1.2%	51,662	4%	6,080	0.4%
N2O	105	1.2%	57,010	5%	294,806	18%
EE Households	102	1.2%	3,742	0.3%	767	0.05%
Afforestation & Reforestation	70	0.8%	2,482	0.2%	11,328	0.7%
Fugitive	56	0.7%	48,540	4.1%	39,370	2.4%
EE Service	36	0.4%	645	0.05%	99	0.006%
Geothermal	35	0.4%	12,401	1.0%	10,163	0.6%
Transport	33	0.4%	4,440	0.4%	2,401	0.1%
Cement	27	0.3%	4,574	0.4%	6,290	0.4%
HFCs	22	0.3%	81,319	7%	539,942	33%
Energy distrib.	22	0.3%	7,260	0.6%	1,576	0.1%
PFCs and SF6	17	0.2%	5,393	0.5%	6,129	0.4%
Mixed renewables	14	0.16%	611	0.1%	23	0.001%
CO2 usage	4	0.05%	91	0.01%	10	0.001%
Tidal	1	0.01%	315	0.03%	1,074	0.1%
Agriculture	1	0.01%	8	0.001%		
Total	8512	100%	1,197,713	100%	1,656,367	100%
HFCs, PFCs, SF& & N2O reduction	144	1.7%	143,721	12%	840,877	51%
Renewables	6063	71%	645,695	54%	463,405	28%
CH4 reduction & Cement & Coal mine/bed	1292	15%	213,499	18%	195,211	11.8%
Supply-side EE	510	6%	109,353	9%	81,816	4.9%
Fuel switch	133	1.6%	69,499	5.8%	56,882	3.4%
Demand-side EE	267	3.1%	9,025	0.8%	4,447	0.3%
Afforestation & Reforestation	70	0.8%	2,482	0.2%	11,328	0.7%
Transport	33	0.4%	4,440	0.4%	2,401	0.14%

Payments for Environmental Goods & Services (PES)

- Asymmetry of information in provision of EGS: Principal-Agent Problem
- Problem with sellers of carbon offset credits:
  - Often an agent intermediary between provider and eventual buyer
  - Often an aggregator
  - Agent has no incentive to ensure compliance
  - Agent has no incentive to police another agent
  - Agent/government could be corrupt
- Problem with ultimate buyers of carbon offset credits
  - content to just satisfy goal of complying with emission reduction targets
  - marketing strategy to enhance company's image
  - purchasing credits out of guilt, mandate or concern for others, but may not care whether it actually impacts global warming

Principal-Agent Relationships and the Contracting of Carbon Offset Credits

Descending order of control over the effectiveness of CO_2 offsets ↓

Principal	Agent	Description/Comment
Landowner	Land user / tenant / peasant ('on-the-ground')	Agent maximizes immediate net returns to land use; principal maximizes present value of net returns in long run. Contract could be informal or non-existent
Aggregator / Contractor	Landowner / farmer	Landowner and land user may be the same agent (as in developed countries). Some form of contract required to present for certification.
Certification Process: Certifier / 'Gatekeeper'		Certifier and aggregator could be linked if governance structure is unable to 'ring a fence' around different aspects of a firm
Seller or Contractor	Aggregator	Seller/contractor and aggregator could be identical
Buyer	Seller	When purchasing offset credits, buyer trusts credits are legitimate and truly reduce atmospheric CO_2, whether true or not

Paris Agreement as an Illustration

- Independent Nationally Determined Contributions:
  - considered by some to be binding (e.g., EU considers them binding, but only EU law is binding, as is California law passed in 2006)
  - Reality: domestic targets are voluntary with no true mechanism that compels adherence to targets
  - Shaming is principal means of ensuring compliance
- Each jurisdiction responsible for its own guidelines/strategies for addressing global warming
- Even if all targets are met, the impact on global warming is extremely small
- Surprisingly, many jurisdictions rely on forestry
  - Russia and China have explicit forestation policies
  - EU to rely on solid biomass (wood) for approx. 45-50% of renewable energy (all biomass to constitute 65% of renewable energy) and 27% of EU energy to come from renewables by 2030 (about 1/8 of EU energy to come from wood by 2030)

Conclusions

- Asymmetric information and PA problem greatest obstacle to use of forestry for mitigating climate change at a global level
  - Governance and transaction costs are major issues that have never been addressed
  - Some research on PES has addressed PA concerns, but no real solution in sight
- My view: If you wish to include forestry, need to employ a tax/subsidy scheme
  - Based on a realistic forest growth, yield, management model that tracks CO_2 release / emissions and uptake
  - Monitoring requires only observations on land use
  - Parties contract to agree to model and associated payment scheme
- Remaining issues:
  - No benefits to biomass burning (pay for CO_2 emissions from burning; no benefit to avoided CO_2 emissions of replaced fossil fuels, except in the fossil fuel sector)
  - No benefits from fossil fuel emissions saved from not making steel/cement when wood substitutes for non-wood materials in construction
  - Benefit to carbon entering wood product pools (e.g., mass timber buildings) – determined from modeling
  - No benefits to forest conservation

At the time of harvest, how much carbon can we count going into a product sink?

r_c = rate used to weight (discount) physical carbon
d = rate at which carbon enters into atmosphere from the decay in the post-harvest product carbon pool
ε = proportion of carbon that goes into the wood product sink *at harvest time*.

After one year, carbon released to atmosphere = $d \times \varepsilon \times C$, where C is the carbon in harvested timber.

Second year, carbon released into atmosphere = $d(1-d) \times \varepsilon \times C$

3rd year, carbon escaping to atmosphere due to decay = $d\,(1-d)^2\,\varepsilon\,C$

Stream of carbon entering the atmosphere is given by:

$$d\,\varepsilon\,C + d\,(1-d)\,\varepsilon\,C + d\,(1-d)^2\,\varepsilon\,C + \ldots = [1 + (1-d) + (1-d)^2 + (1-d)^3 + \ldots]\,d\,\varepsilon\,C.$$

Stream of carbon release over n periods (which needs to be discounted):

$$V_n = \frac{d\varepsilon C}{1+r_c} + \frac{d(1-d)\varepsilon C}{(1+r_c)^2} + \frac{d(1-d)^2\varepsilon C}{(1+r_c)^3} + \frac{d(1-d)^3\varepsilon C}{(1+r_c)^4} + \ldots + \frac{d(1-d)^{n-1}\varepsilon C}{(1+r_c)^n}$$

$$\frac{1-d}{1+r_c}V_n = \frac{d(1-d)\varepsilon C}{(1+r_c)^2} + \frac{d(1-d)^2\varepsilon C}{(1+r_c)^3} + \frac{d(1-d)^3\varepsilon C}{(1+r_c)^4} + \ldots + \frac{d(1-d)^{n-1}\varepsilon C}{(1+r_c)^n} + \frac{d(1-d)^n\varepsilon C}{(1+r_c)^{n+1}}$$

$$\frac{r_c+d}{1+r_c}V_n = \frac{d\varepsilon C}{(1+r_c)} - \frac{d(1-d)^n\varepsilon C}{(1+r_c)^{n+1}} = \left(\frac{1}{1+r_c}\right)\left(1-\frac{(1-d)^n}{(1+r_c)^n}\right)d\,\varepsilon C$$

$$V_n = \left(\frac{1}{r_c+d}\right)\left(1-\frac{(1-d)^n}{(1+r_c)^n}\right)d\,\varepsilon C$$

Let $n \to \infty$: $V_{Crelease} = \lim_{n\to\infty} V_n = \left(\frac{d}{r_c+d}\right)\varepsilon C$

If r_c=0, then all the stored carbon is released

If d = 0, then all carbon is stored forever in products

Since V is the discounted release of carbon at the time of harvest, the amount stored at time of harvest is given by:

$$V_{Cstored} = \varepsilon C - V = \left(1 - \frac{d}{r_c + d}\right)\varepsilon C = \left(\frac{r_c}{r_c + d}\right)\varepsilon C$$

If r_c=0, then no carbon is stored because it is all released. If d=0, then all the carbon is retained regardless of the rate used to weight carbon.