Climate Change Valuation Adjustment (CCVA) using parameterized climate change impacts

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Acknowledgments and Disclaimer

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Outline

Introduction

- Climate change risk comprises physical, transition, and liability risks to assets, companies and sovereign entities[1] (Bank of England 2019; European Central Bank 2020).
- Credit valuation adjustment (CVA) quantifies expected loss on counterparty default (Green 2015; BCBS 2021), and the costs of funding are captured in funding valuation adjustment (FVA), together CVA+FVA.
- CVA and FVA are based on **extrapolation** of credit default swap (CDS) spreads which are typically traded only up to 10 year maturity, and inclusion of bond trading where applicable.
- We introduce Climate Change Valuation Adjustment (CCVA) to capture the difference in expected loss and funding between usual credit information extrapolation and the parameterized inclusion of economic stress from climate change endpoints and transition effects.
- Paper available on SSRN (id=3790098) and published in Risk (Kenyon and Berrahoui 2021).

[1] https://www.bankofengland.co.uk/knowledgebank/climate-change-what-are-the-risks-to-financial-stability

Climate change effects and modeling

- Client transactions, especially project finance for essential infrastructure, can go out 30 years or more so CVA calculation requires extrapolation of CDS spreads beyond 10 years.
- Climate change may impact counterparty default on these timescales (Tol 2018).
- Many authors have modeled the relationship between climate change and default risk, e.g. (Capasso, Gianfrate, and Spinelli 2020) took a structural approach based on a firm's carbon footprint. (Garnier 2020) models physical and transition risks based on rating level transitions driven by a Gaussian copula.
- In contrast, we transpose the problem of modeling into estimation of a small number of directly interpretable parameters.

Contributions

The contributions of this paper are:

- introduction of **Climate Change Valuation Adjustment** to capture climate change impacts on CVA+FVA that are currently invisible assuming typical market practice;
- introduction of a direct, flexible, and expressive **sigmoid parametrization** to capture the path of instantaneous hazard rates to climate change endpoints, and for transition effects;
- **examples of changes in trade pricing** of typical interest where there is risk of economic stress from sea level change, or transition change in business model.

Data limitations driving market practice

Cumulative percentage by index	CDS maturity rounded to neared year									
on DTCC 2021-01-21 to 2021-02-19	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Credit:Index:CDX:CDXEmergingMarkets	0%	0%	0%	7%	100%					
Credit:Index:CDX:CDXHY	0%	1%	2%	5%	100%					
Credit:Index:CDX:CDXIG	0%	1%	3%	9%	98%	98%	98%	98%	99%	100%
Credit:Index:iTraxx:iTraxxAsiaExJapan	0%	0%	0%	9%	100%					
Credit:Index:iTraxx:iTraxxAustralia	0%	0%	0%	20%	100%					
Credit:Index:iTraxx:iTraxxEurope	1%	3%	7%	10%	98%	98%	98%	99%	99%	100%
Credit:Index:iTraxx:iTraxxJapan	0%	0%	0%	0%	100%					
Grand Total	**0.5%**	**1.8%**	**3.9%**	**8.5%**	**98.5%**	**98.6%**	**98.8%**	**98.8%**	**99.0%**	**100.0%**

Table: Cumulative CDS transaction volume for indices referring to corporates on DTCC over a recent 30-day period, 2021-01-19 to 2021-02-20. DTCC is a US Swaps Data Repository so sees mostly US transaction. CDS indices are more traded than single-name CDS.

- Market implied counterparty default probability is inferred from spreads of traded credit default swaps (CDS), augmented by bonds where available. However, few CDS are traded beyond 5 years and almost none beyond 10 years. Many counterparties, e.g. project finance, have no CDS and so are priced and hedged primarily from CDS proxies. For these cases CDS indices are particularly important.
- Table 1 shows volumes for CDS indices from a Swaps Data Repository[2]. CDS indices are more traded than single name but not defined beyond 10 years: we see 98% of trading volume is for maturities up to 5 years.
- Given the lack of data, market practice is to use some form of extrapolation beyond 10 years.
- Ratings may inform bond prices and proxy CDS curves, but corporate ratings typically have a three to five year look ahead (Fitch 2020).

[2] www.dtcc.com

Probability measures

- Since CCVA is based on model predictions rather than tradable instruments it is a $\mathbb{P}$-measure quantity.
- Standard CVA may be thought of as a $\mathbb{Q}$ measure quantity.
- Because of the lack of hedging beyond 5 to 10 years it is a mix between replication-based pricing and a measure represented by the CDS extrapolation. We shall label this measure given by market practice of CDS extrapolation Ξ (Xi for eXtrapolation).
- To discuss, precisely, the origin of Climate Change Valuation Adjustment, in Section 15 we introduce appropriate probability spaces and measures to capture market practice and inclusion of possible climate change endpoints.

Parameterization

- To be able to discuss and compare paths of economic stress to climate endpoints we introduce a sigmoid parameterization of the instantaneous hazard rate evolution $S(1_{\text{transient}}, (t_{\text{start}}, h_{\text{start}});\ m, w;\ u, (t_{\text{end}}, h_{\text{max}}))$, Section 4 gives details. This parameterization is expressive enough to cover different paths of economic stress buildup, see Section 28.
- The parameterization flexibly connects the longest traded CDS maturity and level, with the climate change endpoint, by allowing specification of the mid point m of the stress and the width w of the stress buildup.
- If we specify that instead of ending at a high hazard level the curve returns to the original level, i.e. $1_{\text{transient}}$ is true, then the same parameterization models transient transition effects.
- Thus we capture approach to default and transition with a single set of parameters. These parameters can be specified for each counterparty of a bank for example by by internal risk management, or a regulatory body for all banks, to define climate change scenarios independent of the details of the driving mechanisms.

Examples of climate change impacts

end point: project finance or sovereign or sub-sovereign with significant changes in default probability because of sea level change.

- Includes frequency of storm effects, and considers infrastructure may be below ground level.
- Although sea level rise puts the entity below sea level this may not mean flooding (Estrada, Botzen, and Tol 2017).
- Mitigating actions can be taken, but these create economic stress. CCVA captures this additional economic stress beyond market implied from constant CDS extrapolation.
- Although some aspects of climate change may be in ratings, because the CDS only go out 10 years this either misses later effects, or creates a distorted picture by moving risk beyond 10 years to within 10 years.

transition: entity experiences a limited duration economic stress from transformation of business model.

- We quantify CVA+FVA impacts w.r.t. the mid point of the stress and the width of the stress.
- Same parametrization as the sigmoid curve, but specifying return to normal, rather than ending high.

Outline

Basics of asset pricing

- **Def:** A probability measure $\mathbb{Q}$ is a **risk-neutral** probability measure if
  1. $\mathbb{P}$ and $\mathbb{Q}$ are equivalent.
  2. under $\mathbb{Q}$ all discounted self-financing portfolios are martingales.
- **Def:** An **arbitrage** is a portfolio value process $X(t)$, s.t. $X(0) = 0$ and at $T > 0$:

  $$\mathbb{P}\{X(T) \geq 0\} = 1, \text{ and } \mathbb{P}\{X(T) > 0\} > 0$$

  Can't lose money, do expect to make some.
- **First Theorem:** If a market model has a risk-neutral probability measure then it does not admit arbitrage.
- **Def:** A market model is **complete** if every derivative security can be hedged.
- **Second Theorem:** A market model with a risk-neutral probability measure is complete if and only if the risk-neutral measure is unique.

Market-implied measure and physical measures

- Market data can define a unique market implied measure
- Physical measures are always subjective as they derive from a choice of calibration. The results of these calibrations may have to pass regulatory requirements but regulations are subjectively decided by committees.
- We want to be able to price CVA and FVA as banks normally price them and to price CCVA. For normal bank pricing we introduce the probability space:

$$X = (\Omega, \mathcal{F}, \mathbb{P})$$

on a set of events $\Omega(t)$ with a filtration $\mathcal{F}(t)$ and corresponding probability measures $\mathbb{P}(t)$. The equivalent probability space with a risk-neutral measure, given that the last traded CDS maturity is T, is

$$Y_{Q\Xi}(T) = (\Omega, \mathcal{F}, [\mathbb{Q}; T; \Xi])$$

on events $\Omega_{\leq T} = \Omega(t) s.t.\ t \leq T$ with filtration $\mathcal{F}_{\leq T} = \mathcal{F}(t)\ s.t.\ t \leq T$ and risk neutral measure $\mathbb{Q}$ on $\mathcal{F}_T$. Note that the risk neutral measure only exists for $t \leq T$.

The measure Ξ

- We introduce the measure Ξ for $t > T$ on events $\Omega_{>T} = \Omega(t)\ s.t.\ t > T$ with filtration $\mathcal{F}_{>T} = \mathcal{F}(t)\ s.t.\ t > T$.
- Ξ is defined as a measure in which non-credit items can be hedged but credit items cannot be hedged but are priced assuming that CDS's are extrapolated flat. We assume independence of credit and non-credit events for simplicity.
- Note that Ξ is not $\mathbb{P}$, even for $t > T$. Ξ can be thought of as an extrapolation of $\mathbb{Q}$ following the rule that CDS quotes are extrapolated flat, or according to a Bank's internal methodology. Hence we get:

$$Y_{Q\Xi}(T) = (\Omega, \mathcal{F}, [\mathbb{Q}; T; \Xi])$$

- To capture what may actually happen we introduce the probability space combining the risk neutral measure before T and the physical after T:

$$Y_{QP}(T) = (\Omega, \mathcal{F}, [\mathbb{Q}; T; \mathbb{P}])$$

Actual hedging practice

- A bank can roll CDS hedges, but the roll takes place in the conditional risk neutral $\mathbb{Q}_{\omega,C}$ measure (Kenyon 2020).
- There is a probability space $X_{\omega,C}$ conditioned on events ω up to T in which the client C did not default.
- $\mathbb{Q}_{\omega,C}$ is the equivalent risk neutral probability measure from T, within the conditional probability space $Y_{\omega,C}$.
- $\mathbb{Q}_{\omega,C}$ is not equivalent to $\mathbb{P}(t)$ $s.t.$ $t > T$ because the physical measure includes events where C has defaulted and $\mathbb{Q}_{\omega,C}$ does not.

Outline

Climate Change Valuation Adjustment (CCVA)

- We define CCVA relative to the usual bank calculation of CVA and FVA not the actual hedging cost requiring repeated purchases of CDS at later dates.
- We define CVA and FVA including the measure involved, based on (Burgard and Kjaer 2013) and then specialize these with to define CCVA.

Definition (CVA and FVA under probability space $Y(\Omega, \mathcal{F}, \Gamma)$)

$$\text{CVA}^{Y(\Omega,\mathcal{F},\Gamma)} = \mathbb{E}^{\Gamma}\left[\int_{u=0}^{u=T} L_{GD}(u)\lambda(u)e^{\int_{s=t_0}^{s=u} -\lambda(s)ds} D_{r_F}(u)\Pi^{+}(u)du\right] \quad (1)$$

$$\text{FVA}^{Y(\Omega,\mathcal{F},\Gamma)} = \mathbb{E}^{\Gamma}\left[\int_{u=0}^{u=T} s_F(t)e^{\int_{s=t_0}^{s=u} -\lambda(u)ds} D_{r_F}(u)\Pi(u)du\right] \quad (2)$$

Market practice and including climate change

- The usual market implied CVA and FVA based on market practice are:

Definition (Market practice: CVA_{MP} and FVA_{MP})

$$\text{CVA}_{\text{MP}} = \text{CVA}_{\text{Market Practice}} = \text{CVA}^{Y_{Q\Xi}} = \text{CVA}^{Y(\Omega,\mathcal{F},[\mathbb{Q};T;\Xi])} \tag{3}$$

$$\text{FVA}_{\text{MP}} = \text{FVA}_{\text{Market Practice}} = \text{FVA}^{Y_{Q\Xi}} = \text{FVA}^{Y(\Omega,\mathcal{F},[\mathbb{Q};T;\Xi])} \tag{4}$$

- CVA and FVA including climate change are defined similarly based on probability space used.

Definition (Including climate change: CVA_{CC} and FVA_{CC})

$$\text{CVA}_{\text{CC}} = \text{CVA}_{\text{Climate Change}} = \text{CVA}^{Y_{QP}} = \text{CVA}^{Y(\Omega,\mathcal{F},[\mathbb{Q};T;\mathbb{P}])} \tag{5}$$

$$\text{FVA}_{\text{CC}} = \text{FVA}_{\text{Climate Change}} = \text{FVA}^{Y_{QP}} = \text{FVA}^{Y(\Omega,\mathcal{F},[\mathbb{Q};T;\mathbb{P}])} \tag{6}$$

Definition of Climate Change Valuation Adjustment

- Now we can define CD.CVA and CD.FVA as the difference between the versions including climate change and market implied (i.e. flat CDS extrapolation). The sum of the differences is the CCVA.

Definition (Climate Change Valuation Adjustment, CCVA, and climate change differences in valuation adjustments for credit and funding)

$$\text{CCVA} = \text{CD.CVA} + \text{CD.FVA} \tag{7}$$

$$\text{CD.CVA} = \text{CVA}_{\text{Climate Change}} - \text{CVA}_{\text{Market Practice}} = \text{CVA}^{Y_{QP}} - \text{CVA}^{Y_{Q\Xi}} \tag{8}$$

$$\text{CD.FVA} = \text{FVA}_{\text{Climate Change}} - \text{FVA}_{\text{Market Practice}} = \text{FVA}^{Y_{QP}} - \text{FVA}^{Y_{Q\Xi}} \tag{9}$$

Comments

- These definitions capture what is not in the market implied valuation adjustments.
- If market practice changes so that climate change is included then, e.g. $\text{CVA}_{\text{Climate Change}} = \text{CVA}_{\text{Market Practice}}$, and the differences will be zero.
- Here we highlight was is not currently included.
- Below we estimate the size of CCVA for a particular subset of entities where the calculation may be easiest.
- Note that CCVA will be less than zero for cases where climate change has beneficial effects for the entity concerned.

Now we need to see how to apply these definitions.

Outline

Climate economic effect parametrization

- To be able to discuss and compare paths of economic stress to climate endpoints we introduce a sigmoid parameterization of the instantaneous hazard rate, $\lambda(t)$:

$$\lambda(t) = S(1_{\text{transient}}, (t_{\text{start}}, h_{\text{start}}); m, w; u, (t_{\text{end}}, h_{\text{max}}))$$

- The hazard curve for a counterparty including climate effects consists of two parts
  - Hedgeable section with $\mathbb{Q}$ measure $\lambda(t)$ from traded CDS
  - Sigmoid section in $\mathbb{P}$ measure
- Alternatively, custom $\lambda(t)$ from credit departments using integrated assessment models (Nordhaus 2017; NGFS 2020)

Sigmoid parametrization, stressed endpoint

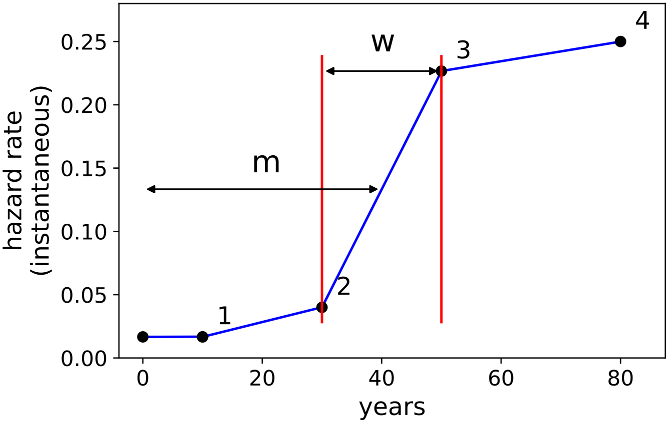


Figure: Sigmoid parameterization for the approach of instantaneous hazard rates to default, $S(1_{\text{transient}}, (t_{\text{start}}, h_{\text{start}}); m, w; u, (t_{\text{end}}, h_{\text{max}}))$, with $1_{\text{transient}}$ False. See Table 2 for details.

Parametrization

Parameter	Example value	Description
$1_{\text{transient}}$	False	
m	40 years	time to mid-impact
w	20 years	width of middle section
$(t_{\text{start}}, h_{\text{start}})$	(10, 0170)	coordinates of end of $\mathbb{Q}$ measure section and start of $\mathbb{P}$ measure section that approaches default
$(t_{\text{end}}, h_{\text{end}})$	(80, 0.2500)	coordinates of end of impact
u	10%	fraction of impact $(h_{\text{end}} - h_{\text{start}})$ for initial increase, and final approach to $h_{\max}$

Point	Definition	
1	$(t_{\text{start}}, h_{\text{start}})$	
2	$(m - w/2,\ h_{\text{start}} + u \times (h_{\max} - h_{\text{start}}))$	
3	$(m + w/2,\ h_{\max} - u \times (h_{\max} - h_{\text{start}}))$	if $1_{\text{transient}} =$ False
	$(m + w/2,\ h_{\text{start}} + u \times (h_{\max} - h_{\text{start}}))$	if $1_{\text{transient}} =$ True
4	$(t_{\text{end}}, h_{\max})$	if $1_{\text{transient}} =$ False
	$(t_{\text{end}}, h_{\text{start}})$	if $1_{\text{transient}} =$ True
5	$(m, h_{\max})$	only present if $1_{\text{transient}} =$ True

Table: Sigmoid parameterization, and point definition, for the approach of instantaneous hazard rates to default, $S(1_{\text{transient}}, (t_{\text{start}}, h_{\text{start}});\ m, w;\ u, (t_{\text{end}}, h_{\max}))$. Note that if the slope of the last section is greater than the slope of the mid section, then point 2 is removed so there is a straight line between point 2 and point 4. See Figure 1 for graphical view using the example parameters.

Sigmoid parametrization, transition effects

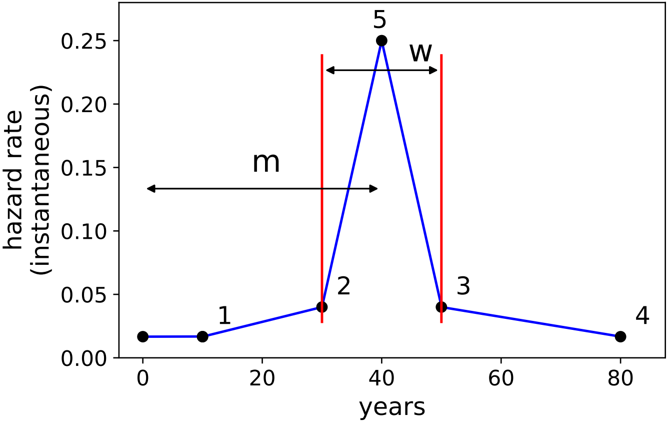
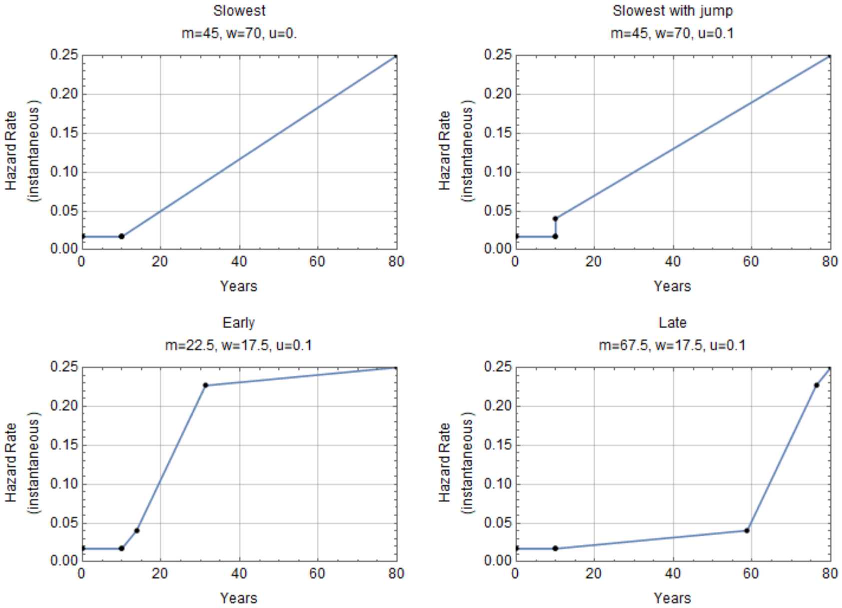


Figure: Sigmoid parameterization for modeling of transition stress uses the same parameters, $S(1_{\text{transient}}, (t_{\text{start}}, h_{\text{start}}); \; m, w; u, (t_{\text{end}}, h_{\text{max}}))$, but now with $1_{\text{transient}}$ True. See Table 2 and Section 27 for details.

Expressivity examples



Outline

Numerical Examples

We quantify effects on at the money (ATM) USD interest rate swaps (IRS) using the examples below:

- First set of cases: the entity has reasonable expectation of default from continually increasing economic stress caused by rising sea level. Examples of such entities include low-lying coastal cities, and associated special purpose vehicles (SPVs) used for essential infrastructure, such as roads, bridges, tunnels, housing, etc.
- Second set of cases: transient transition risks where the mid point economic stress of the transition occurs from 15 to 75 years in the future and has a duration of 1 to 10 years. We do not need to consider transition stresses within 10 years because we assume that single name CDS are traded to 10 years and that the Bank can fully hedge CVA+FVA up to 10 years.

Setup

- asof date 2020-01-29 for USD yield curve, single curve approach. Normal volatility, flat at 20bps.
- uncollateralized trade. This is typical for infrastructure projects via SPVs.
- maximum instantaneous hazard rate at climate change endpoint: 2500 basis points (bps).
- recovery rate on CDS, 40%.
- IRS length: 20 to 50 years.
- Funding spread is 100bps, flat
- We assume traded CDS out to 10 years, flat, at 100 bps.

Endpoint reached in 80 years: Hazard and CDS

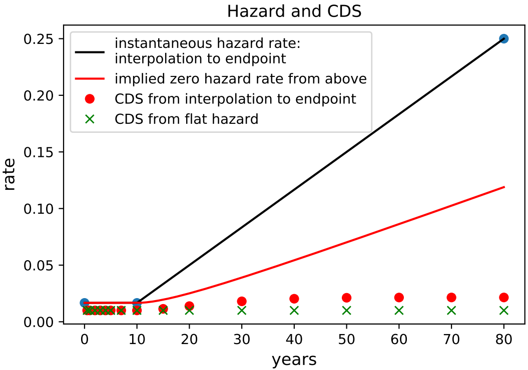


Figure: Slowest uniform approach of instantaneous hazard rate to climate change endpoint in 80 years, starting from CDS of 100bps up to 10 years, and derived zero (average) hazard rate.

Endpoint reached in 80 years: Survival

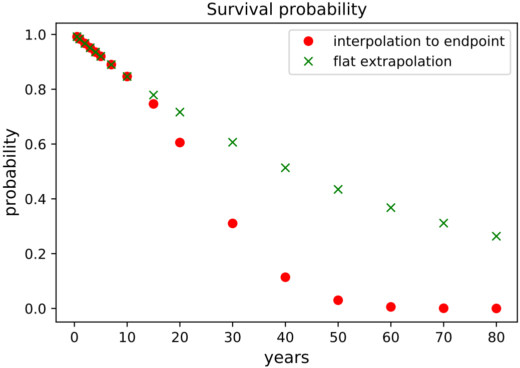


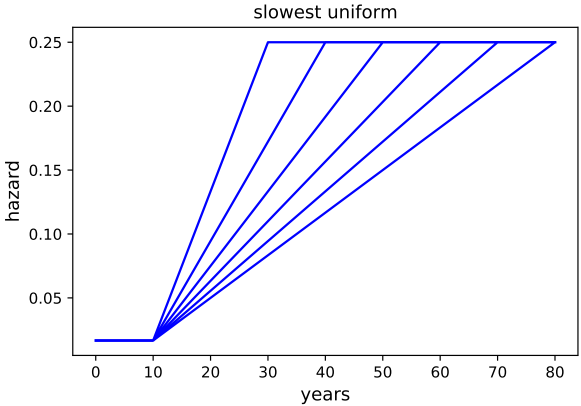
Figure: Slowest uniform approach of instantaneous hazard rate to climate change endpoint in 80 years, starting from CDS of 100bps up to 10 years: derived survival probabilities.

Endpoint reached in 80 years

maturity	CDS (bps)	survival	flat survival
1	100	98.35	98.35
5	100	92.00	92.00
10	100	84.65	84.65
20	138	60.55	71.65
30	180	31.04	60.65
40	203	11.40	51.34
50	212	3.00	43.46
60	214	0.57	36.79
70	215	0.08	31.14
80	215	0.01	26.36

Table: CDS rates implied from slowest uniform approach of instantaneous hazard rate to climate change endpoint in 80 years, starting from CDS of 100 bps up to 10 years. shown in Figure 4. The flat CDS extrapolation is 100bps for all times. Survival probabilities are to the maturity in the first column.

Climate change endpoint reached in 30 to 80 years



- Here we give the CVA+FVA changes considering climate change endpoints at 30 to 80 years against IRS of 20 to 50 year maturities.
- Instantaneous hazard rates increase at the slowest uniform rate, i.e. a straight line from the end of the traded CDS at 10 years to the climate change endpoint.

CVA impacts: endpoint

IRS length (years) width (years)	change in CVA % 20	30	40	50
20	71	141	140	130
30	51	113	117	113
40	39	93	100	100
50	32	80	88	90
60	27	69	78	81
70	23	61	70	74

Table: Slowest uniform increase in hazard rate results. Changes in CVA, i.e. relative sizes of CD.CVA, compared to flat CDS extrapolation.

FVA impacts: endpoint

IRS length (years) width (years)	change in FVA % 20	30	40	50
20	-4	-18	-19	-21
30	-3	-13	-15	-16
40	-2	-11	-12	-14
50	-2	-9	-10	-12
60	-1	-8	-9	-10
70	-1	-7	-8	-9

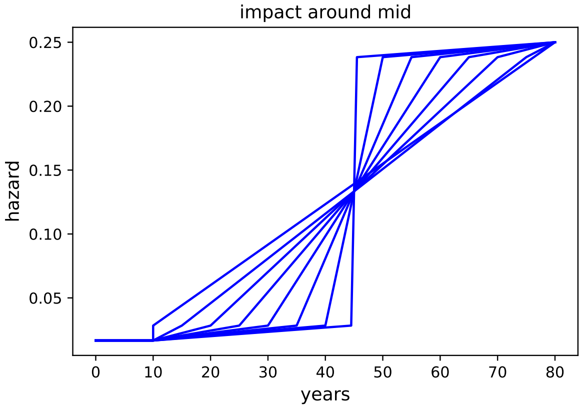
Table: Slowest uniform increase in hazard rate results. Changes in FVA, i.e. relative sizes of CD.FVA, compared to flat CDS extrapolation. Notice that increased hazard rates is beneficial for FVA.

CVA+FVA impacts, i.e. CCVA: endpoint

IRS length (years) / width (years)	CDS slope bps/year	extrapolation of CDS level after 80 years (bps)	change in CVA+FVA % 20	30	40	50
20	125	8333	37	67	73	73
30	83	5611	26	54	62	64
40	63	4250	20	45	53	57
50	50	3433	17	39	47	51
60	42	2889	14	34	42	47
70	36	2500	12	30	38	43

Table: Slowest uniform increase in hazard rate results. Changes in CVA+FVA, i.e. CCVA, compared to flat CDS extrapolation. FVA and CVA are different sizes so the overall result is not a simple average.

Impact around midpoint to 2101



- Here we assume that the impact on the instantaneous hazard rate is around the mid point of the time to the climate change endpoint. We also assume that there is a 5% build-up, i.e. $u = 0.05$.
- Note that there is also a jump in instantaneous hazard rate at the switch from $\mathbb{Q}$ to $\mathbb{P}$ for the slowest increase.

CVA impacts: midpoint

	change in CVA %, **30Y IRS**			
IRS length (years)	20	30	40	50
width (years)				
1	2	8	10	16
10	3	9	11	18
20	3	10	14	24
30	4	13	19	31
40	6	19	29	40
50	8	32	44	53
60	18	54	64	69
70	42	82	88	89

Table: Midpoint increase in hazard rate results. Changes in CVA, i.e. relative sizes of CD.CVA, compared to flat CDS extrapolation.

FVA impacts: midpoint

	change in FVA %, **30Y IRS**			
IRS length (years)	20	30	40	50
width (years)				
1	-0	-1	-1	-1
10	-0	-1	-1	-1
20	-0	-1	-1	-2
30	-0	-1	-2	-2
40	-0	-2	-2	-3
50	-0	-3	-4	-5
60	-1	-6	-6	-8
70	-2	-10	-11	-13

Table: Midpoint increase in hazard rate results. Changes in FVA, i.e. relative sizes of CD.FVA, compared to flat CDS extrapolation. Notice that increased hazard rates is beneficial for FVA.

CVA+FVA impacts, i.e. CCVA: midpoint

	change in CVA+FVA %, **30Y IRS**			
IRS length (years)	20	30	40	50
width (years)				
1	1	4	5	9
10	1	4	6	11
20	2	5	8	14
30	2	6	11	18
40	3	9	16	24
50	4	16	24	31
60	9	26	34	40
70	22	39	46	50

Table: Midpoint increase in hazard rate results. Changes in CVA+FVA, i.e. CCVA, compared to flat CDS extrapolation. FVA and CVA are different sizes so the overall result is not a simple average.

Transition quantification

- Example trade: 30 year IRS.
- We consider mid-transition from 15 years in the future to 75 years in the future, and transition durations of 1 to 10 years.
- Transition stress $t_{\text{mid start}}$ to $t_{\text{mid end}}$, with $u = 0.05$
- Peak hazard rate at 2500bps
- The counterparty has a traded CDS level of 100bps, and we imagine that the counterparty experiences economic stress from changing their business model to adapt to climate change. We further assume that if they overcome the transition period then they have the same risk level as at the start, i.e. 100bps.

CVA and FVA impacts: transition

	change in **CVA %, 30Y IRS**						
time to mid	15	25	35	45	55	65	75
width							
1	47	26	10	8	6	5	4
5	112	54	11	8	6	5	4
10	161	81	13	9	6	5	4

	change in **FVA %, 30Y IRS**						
time to mid	15	25	35	45	55	65	75
width							
1	-7	-2	-1	-1	-1	-0	-0
5	-19	-4	-1	-1	-1	-1	-0
10	-29	-6	-1	-1	-1	-1	-0

Table: Impact of transformation stress for 30 year IRS, depending on timing (mid point) and duration (width).

CVA+FVA impacts, i.e. CCVA: transition

	change in **CVA+FVA %, 30Y IRS**						
time to mid	15	25	35	45	55	65	75
width							
1	22	13	5	4	3	2	2
5	52	27	6	4	3	2	2
10	73	41	6	4	3	3	2

	percent change in survival probability, **30Y IRS**						
time to mid (years)	15	25	35	45	55	65	75
width (years)							
1	-9	-7	-5	-4	-3	-3	-2
5	-34	-27	-21	-16	-13	-10	-8
10	-51	-40	-31	-24	-19	-15	-12

Table: Impact of transformation stress for 30 year IRS, depending on timing (mid point) and duration (width).

Outline

Discussion 1/2

- Introduced **Climate Change Valuation Adjustment** to capture currently invisible economic impact on credit losses and funding from climate change in as much as this is different to market implied CVA+FVA using current CDS extrapolation.
- Set up a rigorous basis both in terms of probability spaces and measure, and in terms of contrast of potential climate change effects with market practice.
- Introduced a **sigmoid parameterization** of the impact of climate change on instantaneous hazard rates. This provides a way to discuss economic impacts in a uniform way, whatever the source of modeling of the economic developments. Captures:
  - Approach to a stressed endpoint, e.g. negative relative sea level
  - Transition stresses, e.g. from transformation of business model to adapt to climate change.
- The sigmoid's parameters can form the basis of discussion with stakeholders, e.g. the risk department, or regulators.

Discussion 2/2

- Numerically: for endpoints
  - Even for climate change endpoints as far away as 2101, if there is the slowest possible uniform increase of hazard rates then there are significant credit impacts even on 20y IRS.
  - Effect on FVA is opposite in sign to the effect of CVA, simply because increased default probability means less time to pay funding costs.
  - Overall effect is still an increase of CVA+FVA.
- Transition effects: depend on when they occur and their duration, but a 20% change in CVA+FVA is not unusual.

Outline

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