

### Why choose CRZ Pricer?

#### A next generation tool with modern architecture and reduced TCO

Legacy tools tend to become overly complex, and are at the same time difficult to understand, costly to maintain, and almost impossible to upgrade.

CRZ Pricer was built from scratch in 2016 with a modern architecture that is naturally simple and efficient:

- It is sound and consistent. There is for instance a unique deal representation as well as a unique market data representation (only one table in the database in each case). This reduces maintainability issues and ultimately TCO for the client.
- ▶ It is thread-safe, which allows parallelisation of all calculations.
- ▶ It is fully testable and tested. This is key to achieve robustness.
- It has a very intuitive API as there is one-to-one correspondence between a GUI action/property and an API function/property (this also allows task scheduling of most functionalities).

### A high performance tool

We believe that performance is a feature. The user experience improves dramatically if he switches from overnight batches to real-time numbers.

At CRZ, we leveraged the auto-differentiation to four different topics: optimisation algorithms, risk calculations, deal allocation of portfolio dependent measures and risk calculations on XVA.

Other optimisations include parallelisation of calculations and the Monte Carlo engine.

### Architecture



# Pricing

### Wide Range of Products

- 50+ currencies
- Interest rates : most products including options, inflation, multi/auto-callable, bonds, ND products
- FX, Equities & Commodities : flow, vanilla options, variance swaps, American barriers, auto-callable
- Credit: CDS, bonds, default baskets, options, tranches. Indices & bespoke portfolios

### State of the art modelling

- Multi-curve discounting framework: discount curves are deduced from CSA, cross-currency basis swaps, or bond and CDS curves when relevant
- Market standards for volatility (e.g. SABR) with support for negative rates, static replication for CMS, many smile interpolations
- Universal Model for exotics (see next slide)

#### Interoperability

- Support of FIX protocol with FIX/FIXML messages
- Support of FpML as well as other XML formats
- Support of many flat file formats
- Mifid 2 Transaction Reporting

NewDeal (Callable	) ×													* X
Price	-1	6 EUR	Discoun	t Curve: EURO	IS	Main Currency	y: EUR	-	Auto Refresh					
Main Exercise	Fees Bre	ak Clai	uses Enve	lope										
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Start Date:	09-oct2017	1	Receive	FLOAT	IBOR	EUR6M		0,00 bp	ADV	1	EUR	820 646	8,21 %	0,820 %
End Date:	09-oct2027	2	Pay	FIXED	STD		1,2508 %	0,00 bp		2	EUR	-1 230 772	-12,31 %	-1,229 %
Notional:	10 000 000,00	2								3	EUR	410 110	4,10 %	0,410 %
Currency:	EUR				1	Calver				11-	_			
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			<	ш			<u> </u>	Help	Jx Solve	~	Apply	Cancel	0,00 %	0,001 %
		簷	Display leg ir	n window 🚽 🖊	Add a leg 🛛 💳	Remove selected	d leg(s) 🥤	Selected	leg(s) Up 🚽 🤅	Select	ed leg(s) Do	wn Its in: 💿 R	eporting Ccy(	Deal/Leg Ccy
										/				

### **Exotic Pricing**

#### Universal Model For exotics

In the same Monte-Carlo simulation, one supports:

- As many underlyings as required in any asset class
- Assets (FX/EQ/CO) in local volatility or local stochastic volatility
- Stochastic (normal) rates with multiple factors
- Stochastic credit spreads with (J)CIR++ dynamics
- Generic and product specific control variates

### Generic Product capabilities

- Callable and auto-callable structures with as many legs as required
- Legs can be of different types, allowing hybrid products
- Payoff script allows to price virtually any structure
- Possibility to add simplified input masks for recurrent structures
- Used for XVA, which can be considered as an exotic on portfolio underlying

New D	eal (Script) (3) 📕 🗙						
Pric	e	243 893 EUR Discount Curve: EURRF	٤	Main Cu	rrency: EUR	▼ Auto Refresh	
Main	Fees BreakC	Clauses Envelope					
Script	Values						
Param	ieters		Table				
	Sea	arch					
	Name	Formula		ExerciseDates	RollDates	Index	Leg
т	8 8 C	RBC .	т	RBC	R B C	R B C	ABC .
▶ 1	NotionalExchange	'None'	C	#19/08/2022#	#23/08/2022#	RollDateIndex(Schedule, RollDates(row))	-Sum('i', Index(row), Index(row + 1), Receive(Notionals[i] * Coverages[i] * PayOffs[i],
2	Und	'EUR6M'	1	#21/08/2023#	#23/08/2023#	RollDateIndex(Schedule, RollDates(row))	-Sum('i', Index(row), Index(row + 1), Receive(Notionals[i] * Coverages[i] * PayOffs[i],
3	Margin	0	2	#21/08/2024#	#23/08/2024#	RollDateIndex(Schedule, RollDates(row))	-Sum('i', Index(row), Index(row + 1), Receive(Notionals[i] * Coverages[i] * PayOffs[i],
4	PayCcy	'EUR'	3	#21/08/2025#	#23/08/2025#	RollDateIndex(Schedule, RollDates(row))	-Sum('i', Index(row), Index(row + 1), Receive(Notionals[i] * Coverages[i] * PayOffs[i],
5	Notional	1000000.0	4	#20/08/2026#	#23/08/2026#	RollDateIndex(Schedule, RollDates(row))	-Sum('i', Index(row), Index(row + 1), Receive(Notionals[i] * Coverages[i] * PayOffs[i],
6	Leverage	1.0	5	i #19/08/2027#	#23/08/2027#	RollDateIndex(Schedule, RollDates(row))	-Sum('i', Index(row), Index(row + 1), Receive(Notionals[i] * Coverages[i] * PayOffs[i],
7	Basis	'Act/360'	6	5 #21/08/2028#	#23/08/2028#	RollDateIndex(Schedule, RollDates(row))	-Sum('i', Index(row), Index(row + 1), Receive(Notionals[i] * Coverages[i] * PayOffs[i],
8	FixingType	'ADV'	7	#21/08/2029#	#23/08/2029#	RollDateIndex(Schedule, RollDates(row))	-Sum('i', Index(row), Index(row + 1), Receive(Notionals[i] * Coverages[i] * PayOffs[i],
9	Period	'6M'	8	#21/08/2030#	#23/08/2030#	RollDateIndex(Schedule, RollDates(row))	-Sum('i', Index(row), Schedule.Length, Receive(Notionals[i] * Coverages[i] * PayOffs[
10	StartDate	#23/08/2021#					
11	EndDate	#23/08/2031#					
12	Calendar	'EUTA'					
13	FixingCalendar	'EUTA'					
14	FixingGap	'2B'					
15	PaymentGap	'0B'					
16	Roll	'ModFoll'					
Funct	ons						
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	Name Variable	es Formula					
т	88c 88c	RBC					
	dd an item						
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Results							
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1	EUR 243	3,893					

Res CCY Price EUR 243,893

### Market Data Contribution

#### Real-Time contribution

- Supports Bloomberg (Terminal, B-PIPE, Data Licence), Reuters and TP ICAP
- Automatic Contribution with threshold
- > Data synchronization as well as integrity check before contribution
- Manual calibration for less liquid markets (IR volatility and correlation)
- Many Calibration methods from various input files (e.g., IR Volatility and Smile, Caps & Floors, FX/EQ/CO Volatility)
- Based on historical data for non observables (e.g. inflation seasonality)

### SDR

- Connection to DTCC and BSDR data feeds
- Integration of these data: pricing, manual calibration

### Interoperability

Thanks to a simple API (essentially one function that supports all types of market data), it is very easy to adapt any existing contribution tool to make it feed CRZ database. Built-in functions make it straightforward in Excel.

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Yield Curve USD3M		<b>4</b>	Y	'ield Cu	rve EUR6	∧ ×				-	×	Yie	ld Cu	ve USD3N	X N				~	×
<ul> <li>Commands</li> </ul>				~	Туре	Te 🔺	Spread	Value	Last	Diff			$\checkmark$	Туре	Te 🔺	Spread	Value	Last	Diff	٦
Start			•	$\checkmark$	MM	6M	0	-0,2019 %	-0,2018 %	-0,01 bp 🔼			$\checkmark$	MM	3M	0	1,1911 %	1,1922 %	-0,11 bp 🔮	5
Stop				$\checkmark$	SW	1Y	0	-0,1933 %	-0,1932 %	-0,01 bp			$\checkmark$	FUT	Z17	0	1,3010 %	1,3038 %	-0,28 bp	
🛃 Contribute				$\checkmark$	SW	2Y	0	-0,1389 %	-0,1390 %	0,01 bp			$\checkmark$	FUT	H18	-0,020	1,3978 %	1,4032 %	-0,54 bp	
Reset Grid				$\checkmark$	SW	3Y	0	-0,0321 %	-0,0321 %	0,00 bp			$\checkmark$	FUT	M18	-0,060	1,5101 %	1,5119 %	-0,18 bp	
Reset parameters				$\checkmark$	SW	4Y	0	0,0907 %	0,0908 %	-0,01 bp			$\checkmark$	FUT	U18	-0,130	1,6269 %	1,6286 %	-0,17 bp	
• Causaa				$\checkmark$	SW	5Y	0	0,2164 %	0,2161 %	0,03 bp			$\checkmark$	SW	18M	0	1,4663 %	1,4706 %	-0,43 bp	
- Source				$\checkmark$	SW	6Y	0	0,3375 %	0,3381 %	-0,06 bp			$\checkmark$	SW	2Y	0	1,5907 %	1,5891 %	0,16 bp	
Provider:	Random			$\checkmark$	SW	7Y	0	0,4616 %	0,4623 %	-0,07 bp			$\checkmark$	SW	3Y	0	1,7585 %	1,7613 %	-0,28 bp	
Source:	BKKK			$\checkmark$	SW	8Y	0	0,5906 %	0,5908 %	-0,02 bp			$\checkmark$	SW	4Y	0	1,8851 %	1,8822 %	0,29 bp	
<ul> <li>Auto Contribute</li> </ul>				$\checkmark$	SW	9Y	0	0,7172 %	0,7182 %	-0,10 bp			$\checkmark$	SW	5Y	0	1,9755 %	1,9791 %	-0,36 bp	
Auto Contribute:				$\checkmark$	SW	10Y	0	0,8340 %	0,8353 %	-0,13 bp			$\checkmark$	SW	6Y	0	2,0615 %	2,0612 %	0,03 bp	
Threshold:		0,1 bp		$\checkmark$	SW	12Y	0	1,0216 %	1,0211 %	0,05 bp			$\checkmark$	SW	7Y	0	2,1367 %	2,1341 %	0,26 bp	
<ul> <li>Parameters</li> </ul>				$\checkmark$	SW	15Y	0	1,2007 %	1,2015 %	-0,08 bp			$\checkmark$	SW	8Y	0	2,1961 %	2,1987 %	-0,26 bp	
Warning Time		60		$\checkmark$	SW	20Y	0	1,3644 %	1,3650 %	-0,06 bp			$\checkmark$	SW	9Y	0	2,2479 %	2,2562 %	-0,83 bp	
smooth Before Contribute				$\checkmark$	SW	25Y	0	1,4425 %	1,4421 %	0,04 bp			$\checkmark$	SW	10Y	0	2,3118 %	2,3065 %	0,53 bp	
	-			$\checkmark$	SW	30Y	0	1,4682 %	1,4706 %	-0,24 bp			$\checkmark$	SW	12Y	0	2,3738 %	2,3858 %	-1,20 bp	
<ul> <li>Historical Contributio</li> </ul>	n			$\checkmark$	SW	35Y	0	1,4794 %	1,4772 %	0,22 bp			$\checkmark$	SW	15Y	0	2,4675 %	2,4625 %	0,50 bp	
<ul> <li>Convexity</li> </ul>				$\checkmark$	SW	40Y	0	1,4702 %	1,4694 %	0,08 bp		•	$\checkmark$	SW	20Y	0	2,5271 %	2,5282 %	-0,11 bp	
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fx Calculate Convexity			-										$\checkmark$	SW	30Y	0	2,5590 %	2,5600 %	-0,10 bp	
													$\checkmark$	SW	40Y	0	2,5459 %	2,5497 %	-0,38 bp	
<ul> <li>Roll Futures</li> </ul>													$\checkmark$	SW	50Y	0	2,5341 %	2,5313 %	0,28 bp 🕟	-
Expiry in days:		15																		_
Roll Futures																				
<ul> <li>Manual Contribution</li> </ul>																				
Views Vield Curve USD3	м		Las	st contr	ibution: 0	5/10/2017	09:48:29					Last	contri	bution: 04	4/09/2017	13:23:36				

### Market Data Viewers

#### Flexible market data screens

- > 70+ market data screens allow to efficiently follow the market, providing full transparency
- > These market data screens are fully configurable and they support real-time update
- Many kind of charts are available: historical data, forwards and volatility smiles, 3D surface
- Relative value indicators allowing to perform a rich/cheap analysis on a full set of market data
- Many statistical indicators: historical (spot/term) volatilities/correlations, PCA

#### **Blotters**

Product-specific blotters on swaptions, caps & floors, FX/EQ/CO options allow to monitor more complex market structures

#### Market Scenarios

- One can define stress scenarios by shifting any market data, e.g. Eur6M +50bp and EURUSD +5%
- More complex scenarios are available, e.g. move SABR beta and recalibrate alpha and rho
- Change of risk representation, e.g. EUROIS can be changed from outright to spread curve
- All the pricer functionalities support markets defined through a scenario

#### Spot Swap Rates $\,\, imes\,$

Basis Swaps 🗙

ΨX

	Maturity	EUROIS	EUR1M	EUR3M	EUR6M	EUR12M
۲	1Y	-0,151 %	-0,540 %	-0,302 %	-0,193 %	0,154 %
	2Y	-0,129 %	-0,525 %	-0,234 %	-0,139 %	0,204 %
	3Y	-0,081 %	-0,506 %	-0,138 %	-0,032 %	0,282 %
	4Y	-0,035 %	-0,460 %	-0,033 %	0,091 %	0,377 %
	5Y	0,038 %	-0,416 %	0,086 %	0,215 %	0,484 %
	7Y	0,276 %	-0,245 %	0,338 %	0,463 %	0,723 %
	10Y	0,637 %	-0,013 %	0,721 %	0,834 %	1,043 %
	15Y	1,079 %	0,269 %	1,147 %	1,203 %	1,349 %
	20Y	1,270 %	0,423 %	1,334 %	1,365 %	1,468 %
	30Y	1,411 %	0,489 %	1,410 %	1,472 %	1,493 %

Maturity	EUR1M	EUR3M	EUR6M	EUR12M
► 1Y	-38,2 bp	-14,8 bp	-4,0 bp	30,2 bp
2Y	-38,9 bp	-10,2 bp	-0,8 bp	33,0 bp
3Y	-41,7 bp	-5,5 bp	5,0 bp	35,9 bp
4Y	-41,9 bp	0,2 bp	12,4 bp	40,6 bp
5Y	-44,8 bp	4,7 bp	17,5 bp	44,0 bp
7Y	-51,7 bp	5,7 bp	18,0 bp	43,7 bp
10Y	-65,0 bp	7,4 bp	18,5 bp	39,1 bp
15Y	-81,4 bp	5,2 bp	10,6 bp	25,1 bp
20Y	-85,3 bp	4,5 bp	7,6 bp	17,7 bp
30Y	-92,8 bp	-2,0 bp	4,0 bp	6,1 bp

\* X

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Swaption Straddles  $\,\times\,$ 

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	Expiry	1Y	2Y	3Y	4Y	5Y	7Y	10Y	15Y	20Y	30Y
۲	1M	4,3 bp	8,7 bp	14,5 bp	24,6 bp	37,4 bp	65,2 bp	109,5 bp	174,9 bp	233,5 bp	345,6 bp
	3M	7,7 bp	16,0 bp	27,0 bp	43,7 bp	67,8 bp	114,0 bp	187,1 bp	290,8 bp	388,2 bp	592,3 bp
	6M	10,9 bp	26,3 bp	47,6 bp	71,4 bp	98,7 bp	161,6 bp	262,6 bp	407,4 bp	532,2 bp	861,6 bp
	1Y	20,1 bp	46,4 bp	78,7 bp	113,3 bp	151,7 bp	241,5 bp	382,8 bp	590,1 bp	775,9 bp	1 177,2 bp
	2Y	42,2 bp	92,4 bp	148,9 bp	209,7 bp	269,4 bp	413,4 bp	627,3 bp	936,2 bp	1 211,8 bp	1 663,5 bp
	3Y	66,3 bp	137,6 bp	217,4 bp	295,8 bp	378,7 bp	567,2 bp	833,0 bp	1 194,9 bp	1 492,0 bp	1 963,9 bp
	4Y	87,5 bp	181,2 bp	277,1 bp	378,6 bp	477,9 bp	694,1 bp	982,7 bp	1 382,9 bp	1 709,3 bp	2 213,8 bp
	5Y	110,4 bp	217,	all [	Pramium	Forward	DV/01	% Delta - \	/olatility	/002	2 403,6 bp
	7Y	140,9 bp	279,		101.2 hrs	0.026.0/	1.00	10.6 %	75 hr	vega 22.hm	2 701,2 bp
	10Y	179,8 bp	354,000	-121 	101,2 DP	0,050 % <del>90 0,170</del>	1,90 90 0,001 T	-10,0 % . 90 <u>-</u> 90 - 10,0 %	сооо, ор	5,2 DP	3 068,8 bp
	20Y	234,9 bp	462,6 bp	684,4 bp	898,7 bp	1 096,5 bp	1 456,3 bp	1 925,3 bp	2 557,4 bp	3 043,9 bp	3 726,4 bp
	30Y	250,7 bp	487,2 bp	705,9 bp	917,7 bp	1 126,5 bp	1 483,3 bp	1 972,0 bp	2 652,6 bp	3 177,0 bp	3 939,4 bp

### Risks & P&L

### **Functionalities**

- Full sensitivities (tenor based)
- Risk explained P&L, with second order P&L explanation through re-computation of the risks at EOD
- Realized P&L with curve-by-curve granularity (second order cross effects are also captured)
- > Portfolio replication tool allowing to generate a portfolio from risks
- Many other reports allow effective risk management of a trading book: fixing reports, option expiry reports, past or future payment reports, security positions, ...
- Scenario analysis and stress testing
- Flexible risk representation

### Highlights

- All measures are computed on deal-by-deal basis
- Results are displayed in a pivot table allowing interactive slicing and dicing of results (up to deal level)
- Risks are calculated thanks to auto-differentiation allowing high performance: the risks of a portfolio of 10,000 swaps of 10 year average maturity will require 0.5 second to compute

Portfolio Content	t Risks ×							-	×
				Grand Total	CHASGB2L	CITTGB2L	🔒 Hidden Fields	H	4 <b>.</b>
⊿ FX Spot Total				9	161	-152 📤			<u></u>
	⊿ FX Spot Tot	al		9	161	-152	🗄 🔛 Deal		
		⊿ FX Spot Tota	I	9	161	-152 🔤	🗉 🚞 Keys		
FX Spot	EV Spot		EURUSD	-275	35	-310			
	TX Spot	FX Spot	GBPUSD	87	-7	94			
			USDCHF	197	133	64			
▲ Yield Curve Tot	Yield Curve Total		-272 233	288 387	-560 621				
	⊿ Delta Total			-195 456	297 002	-492 459			
		⊿ CHF3M Tota		185 050	77 612	107 438			
			3M	-2 241	-829	-1 412		**	
			Z17	-349	-155	-194	💡 Filter Area	🔢 Column Area	
			H18	186	17	170	Shift	Counternarty	
	M18		178	13	165	Shire	counterparty		
		СНҒЗМ	U18	137	-8	146			
			2Y	-375	1 223	-1 598			
			3Y	-936	1 254	-2 191			
			4Y	-2 318	75	-2 393			
			5Y	248	-35	283			
			6Y	5 018	3 048	1 970			
			7Y	4 343	-1 837	6 180			
			8Y	6 374	-3 450	9 825			
Vield Curve			9Y	17 373	-479	17 852			
field curve	Delta		10Y	40 026	9 135	30 891	🧮 Row Area	∑ Data Area	
			12Y	38 957	17 963	20 994	Type	Rick	
			15Y	23 616	764	22 853		NISK	
			20Y	6 749	-12 409	19 158	lable 🔺		
			25Y	48 061	63 321	-15 260	Name 🔺		
		▲ CHF6M Tota	l .	51 001	40 269	10 732	Row 🔺		
			6M	-1 783	-1 075	-708			
			1Y	532	-5	537			
			2Y	1 626	-66	1 691			
			3Y	1 027	1 530	-503			
		CHF6M	4Y	2 064	1 387	677			
			5Y	1 792	2 681	-889			
			6Y	-3 266	-1 268	-1 999	Defer Lavout Undate		
			7Y	820	-2 723	3 543 💌		Undate	

### Value-at-Risk

### **Functionalities**

- Historical or Monte-Carlo
- Scenario generation from historical market data or shock flat files
- Volatility Scaling
- Many options are available for fine-tuning and to fit CCP methodologies
- > P&Ls can be calculated as PV differences or as a first order risk explanation
- Monte-Carlo VaR: Implementation with fat tails (t-Student distribution) available

### Highlights

- High performance thanks to risk engine: no need to compute all scenarios
- Marginal allocation up to deal level
- A Risk explained is available: i.e., one can compute for each sensitivity its marginal impact on the Var/ES
- Major variance reduction in MC VaR (Importance sampling and stratification)
- > The generation of present market data from past data preserves exactly the forwards

Risks	[-2 5	27 45	1]
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Historical VaR [40 653 805]

HVaR Risk Explained [40 653 805] 📕 🗙

				Grand Total					
				Risk	Marginal Impact	Measure	Percentage		
Grand Total				-2 527 451	3,209	40 653 805	100,00 %		
FX_Spot				7 882					
⊿ Yield_Curve Total				-2 535 333	3,248	40 653 805	100,00 %		
	⊿ Delta Total			-1 457 528	14,589	32 647 432	80,31 %		
		CHFOIS		-1 440 077	-0,002	-33 165	-0,08 %		
		EURRFR		639 860	46,163	32 473 759	79,88 %		
		GBPOIS		-428 418	-0,053	50 451	0,12 %		
				-228 892	0,953	156 387	0,38 %		
			3M	-241	-0,690	166	0,00 %		
			6M	159	0,223	35	0,00 %		
			1Y	-9 990	2,243	-22 410	-0,06 %		
	Delta		2Y	66 947	2,570	172 038	0,42 %		
	Dena		3Y	24 221	1,925	46 636	0,11 %		
		LISDRER	4Y	-12 260	1,497	-18 358	-0,05 %		
		03DKIK	5Y	-26 953	1,189	-32 042	-0,08 %		
			7Y	128 511	0,837	107 617	0,26 %		
			10Y	113 408	0,566	64 197	0,16 %		
Vield Curve			15Y	309 662	0,397	122 808	0,30 %		
licid_conve			20Y	-508 726	0,364	-184 951	-0,45 %		
			30Y	-313 630	0,317	-99 350	-0,24 %		
	⊿ Spread Total			-1 077 805	-0,675	8 006 374	19,69 %		
		CHF XCCY		-85 340	0,494	-12 448	-0,03 %		
		▷ CHF3M		-1 703 631	0,531	-186 262	-0,46 %		
		▷ CHF6M		31 202	0,417	-31 026	-0,08 %		
		EUR XCCY		-341 183	0,359	-18 124	-0,04 %		
		▷ EUR3M		1 128 920	-0,449	-97 069	-0,24 %		
	Spread	▷ EUR6M		-80 391	4,107	5 249 131	12,91 %		
	opread	GBP XCCY		15 483	0,157	2 346	0,01 %		
		▷ GBP3M		-1 140 455	-14,787	3 051 523	7,51 %		
		▷ GBP6M		1 116 475	0,100	32 495	0,08 %		
		▷ USD3M		61 828	0,079	-6 494	-0,02 %		
		▷ USD6M		69 148	-0,396	24 922	0,06 %		
		USDOIS		-149 861	0,042	-2 621	-0,01 %		

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Defer Layout Update

Update

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### XVA

### **Functionalities**

- All XVA measures (CVA, DVA, FVA, MVA, KVA) as well as exposures (EE, NEE, PFE, ...)
- FVA is fully configurable as there is currently no market consensus
- Full XVA risks (tenor based) are available for efficient dynamic hedging
- Incremental impacts of deals can be calculated without re-computing the whole netting set
- Marginal allocation up to deal level allows you to instantly view the main contributors to any measure
- Wrong-way risk is supported
- Exotic CSA features such as one-way, non zero thresholds, minimum transfer amounts are supported

### Highlights

- ► The Monte Carlo engine is strongly optimized. American Monte Carlo (AMC) is the most effective calculation approach for XVA, and it is combined with vectorisation to achieve maximal performance.
- Full XVA risks are obtained through pathwise auto-differentiation, so we combine the benefits of a better accuracy (pathwise differentiation) with the spectacular performance of auto-differentiation.
- Specific care has been spent on the quality of regression in AMC so that the underlying distributions are preserved as much as possible.
- Flow compression to allow fast calculations even on large netting sets
- > Overall, performance allows a real-time experience as opposed to reliance on overnight batches only.

	-						_		
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	EFV	EE	NEE	EPE	EEPE	PFE	Vo	🕀 🥅 Deal	
Grand Total	-228 061 097	82 244 337	-310 305 433	75 320 610	90 210 082	949 182 493			
04-nov2017	-3 548 155	21 528	-3 569 683	21 528	21 528	800 106			,,,,
04-déc2017	-3 532 973	142 569	-3 675 542	81 056	81 056	2 638 835		S Filter Area	E Column Area
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04-avr2018	-4 494 904	531 010	-5 025 914	346 285	346 285	7 615 218	=		Population
04-juil2018	-4 526 920	905 582	-5 432 502	532 717	532 717	11 344 447			
04-oct2018	-4 520 709	1 275 820	-5 796 529	720 020	720 020	13 782 900			
04-janv2019	-4 548 121	1 729 232	-6 277 353	923 187	923 187	15 544 093			
04-avr2019	-5 338 478	1 844 171	-7 182 649	1 074 720	1 074 720	18 424 172			
04-juil2019	-5 363 130	2 090 681	-7 453 811	1 219 630	1 219 630	19 524 793			
04-oct2019	-5 362 556	2 435 237	-7 797 793	1 372 830	1 372 830	23 331 429		III Row Area	Data Area
04-janv2020	-5 374 928	2 669 696	-8 044 624	1 517 978	1 517 978	22 876 005		Date 🔺	EFV 🛆
04-avr2020	-6 039 931	2 539 900	-8 579 831	1 619 834	1 632 771	22 407 911			FF
04-juil2020	-6 047 356	2 711 670	-8 759 027	1 718 795	1 730 560	25 231 727			
04-oct2020	-6 125 992	2 893 268	-9 019 260	1 817 382	1 828 159	24 815 638			NEE
04-janv2021	-6 134 517	3 037 899	-9 172 416	1 911 901	1 921 843	28 329 942			EPE
04-avr2021	-6 842 223	2 743 236	-9 585 460	1 970 445	2 000 438	29 165 177			<b>Y</b>
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### Capital: Basel 2.5 & FRTB

### **Functionalities**

- Most Basel 2.5 measures (VaR, sVaR, IRC, CEM, SA-CCR, CCR-IMM, CVA-SA, CVA-IMM)
- All FRTB SA measures (SBM, DRC, RRAO, SA-CVA, BA-CVA)
- All FRTB IMA measures (ES, DRC), where non modellable risk factors are configurable
- P&L attribution
- ▶ View aggregated measure and deal-by-deal components (PV, risk weight, ...)
- A capital dashboard allows the aggregation of all the capital measures

### Highlights

- High performance risk engine for FRTB SA
- Marginal allocation up to deal level
- For measures defined as a function of sensitivities, ability to perform a risk explanation
- Capital optimization through risk reduction is possible. Marginal impact of risks in FRTB SA is a dedicated view allowing this kind of optimization. Incremental impact of deals is another solution.
- For historical VaR, the generation of present market data from past data preserves exactly the forwards

Po	rtfoli	io C	ont	ent

Risks

Results

Risks

MR - SBM (Sensitivity Based Method)  $\times$ 

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🔠 Column Area

∑ Data Area GIRR FX CSR Capital

Update

		Grand Total	Grand Total							
		GIRR	FX	CSR	Capital					
I Total Total		40 914 367	859 632		41 773 999	^				
	176	-1 016			-1 016					
	177	-1 030			-1 030					
	178	-1 025			-1 025					
	196	-1 016			-1 016					
	197	1 030			1 030					
	217	-1 027			-1 027					
	238	1 030			1 030					
	258	-1 025			-1 025					
	276	-3 427	10 051		6 624					
	277		300		300					
	278	2 353	-259		2 094					
	296		298		298					
	297		-300		-300					
	298	-2 353	259		-2 094					
	316		298		298					
	317		300		300					
al	318	-2 353	259		-2 094					
	336	-5 634	1 022		-4 612					
	337	5 657	-1 022		4 635					
	338	-4	-1 056		-1 060					
	356	9 813	35		9 848					
	357	116	480		596					
	358	111	481		592					
	376	38 777			38 777					
	377	-37 657			-37 657					
	378	39 112			39 112					
	396	-38 777			-38 777					
	397	37 657			37 657					
	398	-37 586			-37 586					
	416	-42 691			-42 691					
	417	43 041			43 041					
	418	42 975	0	0	42,975	Y				

# Initial Margin

### **Functionalities**

- SIMM for bilateral initial margin: versioning is included and underlying risks are converted in CRIF format. CRIF results are displayed together with the aggregated SIMM measure.
- Historical VaR/ES for cleared OTCs (e.g. LCH is an ES on 2500 dates)
- SPAN for listed products
- CCP basis spreads (such as CME vs LCH) are taken into account
- > An initial margin dashboard allows the aggregation of all the different measures

### Highlights

- High performance risk engine for SIMM
- Marginal allocation up to deal level
- Marginal impact of risks allowing initial margin optimisation
- Linked to MVA to see the expected cost of initial margin over the lifetime of a trade
- For historical VaR, the generation of present market data from past data preserves exactly the forwards

							Grand Total		
							Amount	Amount in USD	
RatesFX Total							-202 860	-240 531	^
4	Risk_IRCurve Te	otal	-195 456	-231 752					
		⊿ CHF Total		266 836	316 388	Ξ			
			⊿ 1 Total			266 836	316 388		
				⊿ 10Y Total			101 445	120 283	
					⊿ Libor3M Tot	al	83 864	99 438	
					Libor3M	EUR	83 864	99 438	
				107	⊿ Libor6M Tot	al	-12 885	-15 277	
				101	Libor6M	EUR	-12 885	-15 277	7 3 3
					⊿ OIS Total		30 465	36 123	
					OIS	EUR	30 465	36 123	
				⊿ 15Y Total			-10 332	-12 250	
					⊿ Libor3M Tot	al	39 203	46 483	
					Libor3M	EUR	39 203	46 483	
				15Y	⊿ Libor6M Tot	al	-22 581	-26 774	
					Libor6M	EUR	-22 581	-26 774	
					⊿ OIS Total		-26 954	-31 959	
esFX Die	ck IPCupie				OIS	EUR	-26 954	-31 959	
1112	sk_incuive	CHF	1	⊿ 1M Total		113	134		
			1	1M	⊿ Libor3M Tot	al	91	108	
					Libor3M	EUR	91	108	
					⊿ OIS Total		22	26	6 6
					OIS	EUR	22	26	
				⊿ 1Y Total			1 013	1 201	
					⊿ Libor3M Tot	al	677	803	
					Libor3M	EUR	677	803	
				1V	⊿ Libor6M Tot	al	532	630	
					Libor6M	EUR	532	630	
					⊿ OIS Total		-196	-232	
					OIS	EUR	-196	-232	
				⊿ 20Y Total			122 508	145 257	
					⊿ Libor3M Tot	al	30 780	36 496	_
				207	Libor3M	FLIR	30 780	36.496	~

▼ X

### Interest rates products & modelling

### Products

- Swaps (outright, OIS, basis, cross-currency, non deliverable), FRAs, Bonds
- Swaptions (vanilla/amortized/forward start), caps & floors, binary options
- ▶ CMS, CMS Spread, Quanto swap & options
- Futures: STIR/Bond/Deliverable Swap/Eris. STIR and bond future options
- Inflation: bonds, ZC swap, YOY swap & options
- Generic Callable notes : Bermudian swaptions, callable range accruals, callable spread options, multi / auto-callable notes

### Models

- Multi-curve discounting framework: discount curves are deduced from CSA, cross-currency basis swaps, or bond and CDS curves when relevant
- Shifted SABR for volatility with support for negative rates
- static replication for CMS/Quanto/In arrears
- Multi factor Gaussian HJM for multi/auto-callable products



# FX products & modelling

### Products

- ► FX outright (spot/forward/NDF), FX swaps, FX Futures
- Vanilla options, NDOs, Future options
- Variance/volatility/gamma swaps, corridors and options
- American single & double barriers, No-touch/single touch, lookbacks
- Generic auto-callable

### Models

- Numerous smile interpolations: Linear/Cubic spline, AFI, SVI, Vanna/Volga
- Event weights, support of market conventions for delta, market strangle
- Flexible FX forward curve: defined through XCCY basis swaps or FX points
- ▶ For non deliverable currencies, Offshore/Onshore market
- Exotics: local volatility and local stochastic volatility, stochastic rates supported
- Vanna/Volga also available for mild exotics

FX Volatility	д	FX	Volatility	×												
Search	Reduced		Expiry	5P	10P	15P	20P	25P	30P	35P	40P	45P	ATM	45C	40C	35C
<ul> <li>Commands</li> </ul>			1W	4 7.08 %	<b>-</b> 6.75 %	4 6.67 %	6.65 %	6.68 %	6.72 %	6.78 %	6.86 %	6.95 %	7.06 %	<b>1</b> 7.20 %	1.37 %	1.58 %
😋 Calculate		E	1M	7.46 %	7.10 %	7.00 %	1 6.99 %	1.01 %	4 7.06 %	4 7.12 %	4 7.20 %	4 7.30 %	7.41 %	1.56 %	7.74 %	7.97 %
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Duplicate			3M	8.27 %	7.79 %	7.65 %	7.61 %	7.61 %	7.65 %	7.71 %	7.78 %	7.88 %	7.99 %	1 8.15 %	1 8.35 %	1 8.59 %
2 Help			6M	8.86 %	8.33 %	8.15 %	8.10 %	8.10 %	8.13 %	8.18 %	8.26 %	8.35 %	8.47 %	8.64 %	8.84 %	9.10 %
Fit Grid To MarketDat	a		9M	9.19 %	8.65 %	8.47 %	8.41 %	8.41 %	8.44 %	8.50 %	8.57 %	8.67 %	8.78 %	8.96 %	9.17 %	9.44 %
all 3D Surface			1Y	9.28 %	8.75 %	8.57 %	8.52 %	8.52 %	8.56 %	8.61 %	8.69 %	8.79 %	8.90 %	9.09 %	9.31 %	9.58 %
Export To CSV			2Y	9.69 %	9.16 %	8.98 %	8.92 %	8.92 %	8.94 %	8.99 %	9.06 %	9.15 %	9.24 %	9.40 %	9.62 %	9.89 %
			3Y	9.80 %	9.38 %	9.24 %	9.20 %	9.21 %	9.24 %	9.28 %	9.35 %	9.43 %	9.51 %	9.65 %	9.85 %	10.10 %
<ul> <li>Market</li> </ul>			4Y	1.94 %	1.60 %	1.49 %	9.46 %	9.47 %	9.50 %	4 9.55 %	9.61 %	4 9.68 %	9.75 %	1.88 %	10.06 %	10.29 %
Market:	Base •		5Y	10.20 %	9.88 %	9.77 %	1.74 %	9.74 %	9.77 %	9.81 %	9.86 %	9.92 %	9.98 %	10.09 %	10.27 %	10.48 %
Subtract Base Scenario:			7Y	10.36 %	10.15 %	10.10 %	10.10 %	10.12 %	10.16 %	6 10.22 %	10.28 %	10.35 %	10.40 %	10.50 %	10.69 %	10.92 %
Auto Refresh:	V		10Y	10.64 %	10.47 %	10.44 %	10.45 %	10.49 %	10.53 %	6 10.59 %	4 10.65 %	10.73 %	4 10.91 %	10.84 %	11.05 %	11.30 %
			15Y	10.61 %	10.46 %	10.44 %	10.45 %	4 10.49 %	10.53 %	6 10.59 %	10.65 %	10.72 %	10.91 %	10.76 %	10.99 %	11.25 %
<ul> <li>Parameters</li> </ul>			20Y	10.61 %	10.46 %	10.43 %	10.45 %	10.49 %	10.53 %	4 10.59 %	10.65 %	10.71 %	10.91 %	10.68 %	10.93 %	11.21 %
Pair:	EURGBP -		25Y	10.60 %	10.46 %	10.44 %	10.45 %	10.49 %	4 10.53 %	6 10.58 %	10.64 %	4 10.70 %	10.91 %	10.58 %	10.87 %	11.17 %
Premium Currency:	EUR 👻		30Y	10.60 %	10.46 %	10.44 %	10.45 %	10.49 %	10.53 %	4 10.58 %	10.64 %	10.70 %	10.91 %	10.55 %	10.80 %	11.13 %
Delta Type:	Premium Included 🔹															

Relative Value

Spot Delta Until:

Premium Type:

Output

Forward ATM After:

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Output:

😋 Calculate Relative Value

Historical Chart In ToolTip:

1Y

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Spot

Volatility

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# Credit products & modelling

### Products

- CDS (single name & index), Corporate bonds, index skew, bespoke portfolio
- Default swaptions
- Multi-name exotics: Default basket and single tranche
- Credit Linked Notes, including callable ones
- Structured notes (e.g., callable on CMS spread option with corporate issuer)
- Convertible bonds

### Models

- ISDA Model to properly model Quoted spread
- Support of Quanto CDS through recovery per currency, idem for seniority, restructuring
- Multi-name exotics: Base correlation smile with arbitrage free interpolation
- Multi-name exotics: LHP, Binomial and Exact pricing methods
- Bespoke portfolio: different index mapping strategies available
- Stochastic credit spreads with (J)CIR++ dynamics
- Illiquid credit issuer: efficient cross-section projection in rating/region/sector



# Equity products & modelling

### Products

- Equity and Indices, outright(spot/forward), EQ swaps, EQ & Dividend Futures
- Vanilla options, Future options
- Variance/volatility/gamma swaps, corridors and options
- American single & double barriers, No-touch/single touch, lookbacks
- Generic auto-callable, Phoenix
- Convertible bonds

### Models

- Affine discrete dividends, continuous dividends
- Dividend taxation taken into account
- Numerous smile interpolations: Linear/Cubic spline, AFI, SVI. Event weights
- Exotics: local volatility and local stochastic volatility, stochastic rates supported
- Convertible bonds: Equity to Credit model with local volatility

#### 🔔 CRZ Pricer - localhost:5000

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🛃 Save As		Equity:	DAX	-	Calendar:	EUTA	•	Date:	23-Aug-2021	·
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Open Market Data										
Open Market Data Analysis	~									

# Commodity products & modelling

### Products

- Forwards, Futures & Swaps
- Vanilla & Asian options, Swaptions, Future options
- Variance/volatility/gamma swaps, corridors and options
- American single & double barriers, No-touch/single touch, lookbacks
- Generic auto-callable
- Swings

### Models

- Numerous smile interpolations: Linear/Cubic spline, AFI, SVI. Event weights
- Exotics: local volatility or local stochastic volatility plus stochastic rates and convenience yields with unlimited number of factors
- Swings pricing methods: Least Square Regression, Rolling Intrinsic (minorant), Perfect foresight (majorant)

#### 🔈 CRZ Pricer - localhost:5000

File Deal Portfolio Market Data Tools He	lp	Quick Launch: Search	-				
差 Edit Market Set: CRZ LOCAL LIVE 🖓 📕		😋 Refresh Market 🕖 F	Pricing Parameters Re	eal Time: 📃			
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Price		Main rees bre	eakciauses Envelop	Deteile			
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n Details		Commodity:	Dutch TTF Gas •	Pay CCY:			
ave Save		Flow Start Date:	01-Sep-2021 •	Payment Gap:	1B		
🛃 Save As		Flow End Date:	01-Sep-2022 •	Calendar:	EUTA 🔹		
Reports		Strike:	13.321	Fixing Ref:	-		
$f_x$ Solver		Unit:	MWh •	Average Details			
Duplicate		Min Global Amount:	0.00	Specified Price:	Close •		
Reset Defaults	Ξ	Max Global Amount:	100.00	Delivery:	Nearby Future 🔻		
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Audit		Results					
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Views New Deal (Commodity Swing) (2)							
				/			

### Performance and Consistency

### Performance

- Fully multi-threaded architecture. Calculations run in parallel
- Autodiff with 4 applications (calibrations, risks, marginal allocation, XVA risks)
- Monte-Carlo is American and vectorized
- One single call to the database to load all the market data required for a portfolio

### Consistency and reliability

- One-to-one correspondence between the API and the GUI
- API fully testable. Test coverage close to 100%
- > API can be 'instrumented' : user defined macros, task scheduling
- Automatic API code generation, like in Excel record a macro
- Most of the code regarding FX, Equities and Commodities is shared
- Most of the GUI is automatically generated, ensuring consistent look and feel
- Many hidden admin tools ensure efficient daily or periodic maintenance
- Straightforward release cycle (no branches). Same day bug fix in case of emergency

### Performance Results

Category	View	Details	Tim e (s)	# Results	Size on disk(MB	Comment
					)	
Risks	Risks	10,000 swaps	0.5	300,000	9.6	
P&L	Realized	10,000 swaps	2.6	42,500	1.2	40 revals
XVA	PV Grid	500 deals	0.9	45	~0	1000 paths, not dbd
XVA	PV Grid	500 deals	1.8	45	~0	5000 paths, not dbd
XVA	PV Grid	500 deals	1.5	16,000		1000 paths, dbd
XVA	Risk Grid	250 deals	5.0	45	~0	1000 paths, 1 factor
XVA	Risk Grid	500 deals	34.5	45	~0	1000 paths, 7 factors
XVA	Risk Grid	10,000 deals	63	180	~0	1k paths, 7 fact, flow compression
IM	SIMM	5000 deals	0.6	150,000		dbd
IM LCH	hVaR	1,500 swaps	26.4	3.75m		2,500 dates
Capital	SBM	10,000 deals	0.8	170,000	5	+0.7s for dbd
Capital	CEM	10,000 deals	0.7	10,000		

Results obtained with an i7-5960X processor (8 cores) and 16 Go of RAM

### Contact

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