Manual

June 2019

Version 1.0



# Index

#### 1.0 **Derivatives Calculations**

4

1.1 Formulas For Derivative Calculations 4 16

1.2 Real-Time Calculations

2.0	Dei	rivatives Price Info	24
	2.1	Menu Bar	24
	2.2	Tool Bar	24
	2.3	Underlying Pane	25
	2.4	Futures Pane	25
	2.5	Options Panes	26
	2.6	Select a new underlying instrument	/index29
	2.7	Adding options by expiry date	29
	2.8	Embedded Order/Price Depth	31

#### **1.0** Derivatives Calculations

The BTS<sup>®</sup> financial library allows users to calculate theoretical (fair) prices, risk ratios or **Greeks** (Gamma, Delta, Rho, Theta, Vega), implied volatility and implied interest rate for derivative instruments on a real-time basis by subscribing to underlying and instrument prices. A specific tool: **Options Calculator** is also available for one-off calculation of the above-mentioned values for any individual option.

#### **1.1 Formulas For Derivative Calculations**

Formulas used in real-time and one-off calculations of forwards/futures and options abide by the definitions made available in the following books: John C. Hull - Options, Futures, and Other Derivatives (Fifth Edition), 2003, Paul Wilmott -Quantitative Finance, 2001 and Patrick Cusatis & Martin Thomas - Hedging Instruments & Risk Management, 2005.

#### 1.1.1 Black-Scholes

The Black-Scholes model has been developed in 1973 to value European options on stocks. Formulas used for call/put options on non-dividend-paying stocks are as follows (refer to chapters 12 and 14 of: John C. Hull - Options, Futures, and Other Derivatives (Fifth Edition), 2003):

$$c = S_0 N(d_1) - K e^{-rT} N(d_2)$$

$$p = Ke^{-rT}N(-d_2) - S_0N(-d_1)$$

with:

$$d_{1} = \frac{\ln\left(\frac{S_{0}}{K}\right) + \left(r + \frac{1}{2}\sigma^{2}\right)T}{\sigma\sqrt{T}}$$
$$d_{2} = \frac{\ln\left(\frac{S_{0}}{K}\right) + \left(r - \frac{1}{2}\sigma^{2}\right)T}{\sigma\sqrt{T}} = d_{1} - \sigma\sqrt{T}$$

 $\sigma \sqrt{T}$ 

where:

N(x) is the cumulative probability distribution function for a standardized normal distribution. In other words, it is the probability that a variable with a standard normal distribution will be less than x:

$$N(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{1}{2}z^{2}} dz \quad ;$$

c is the call price;

**p** is the put price;

 $\mathbf{S}_{0}$  is the stock price;

K is the strike price;

r is the continuously compounded risk-free rate;

 $\sigma$  is the stock price volatility:

**T** is the time to maturity of the option.

Risk ratios or *Greeks* are:

$$\gamma = \frac{N'(d_1)}{S_0 \sigma \sqrt{T}} \quad \text{with} \qquad N'(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$$
[Gamma]  

$$\delta_c = N(d_1)$$
[Delta for call options]  

$$\delta_p = N(d_1) - 1$$
[Delta for put options]  

$$\theta_c = -\frac{S_0 N'(d_1)\sigma}{2\sqrt{T}} - rKe^{-rT}N(d_2)$$
[Theta for call options]  

$$\theta_p = -\frac{S_0 N'(d_1)\sigma}{2\sqrt{T}} + rKe^{-rT}N(-d_2)$$
[Theta for put options]  

$$rho_c = KTe^{-rT}N(d_2)$$
[Rho for call options]  

$$rho_p = -KTe^{-rT}N(-d_2)$$
[Rho for put options]

$$v = S_0 \sqrt{T} N'(d_1)$$

[Vega]

For a dividend-paying stock with the assumption that the amount and timing of the dividends during the life of the option can be predicted with certainty, the Black-Scholes formula can be used provided that the stock price (spot) is reduced by the present value of all the dividends during the life of the option, the discounting being done from the ex-dividend dates at the riskfree rate. A dividend is counted as being during the life of the option only if its ex-dividend date occurs during the life of the option.

The Black-Scholes formulas for the prices of call/put options on stocks providing a dividend yield at rate q are as follows (refer to chapters 13 and 14 of: John C. Hull - Options, Futures, and Other Derivatives - (Fifth Edition), 2003 and chapter 10 of: Paul Wilmott - Quantitative Finance, 2001):

$$c = S_0 e^{-qT} N(d_1) - K e^{-rT} N(d_2)$$
$$p = K e^{-rT} N(-d_2) - S_0 e^{-qT} N(-d_1)$$

with:

$$d_1 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r - q + \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}} \qquad \qquad d_2 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r - q - \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

Risk ratios or Greeks are:

 $\gamma = \frac{N'(d_1)e^{-rT}}{F_0\sigma\sqrt{T}}$ 

 $\delta_c = e^{-qT} N(d_1)$ 

$$l_2 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r - q - \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

[Gamma]

[Delta for call options]

$$\begin{split} &\delta_{p} = e^{-q^{T}} \Big[ N(d_{1}) - 1 \Big] & [\text{Delta for put options}] \\ &\theta_{c} = -\frac{S_{0} N'(d_{1}) \sigma e^{-q^{T}}}{2\sqrt{T}} + q S_{0} N(d_{1}) e^{-q^{T}} - r K e^{-r^{T}} N(d_{2}) & [\text{Theta for call options}] \\ &\theta_{p} = -\frac{S_{0} N'(d_{1}) \sigma e^{-q^{T}}}{2\sqrt{T}} - q S_{0} N(-d_{1}) e^{-q^{T}} + r K e^{-r^{T}} N(-d_{2}) & [\text{Theta for put options}] \\ &r ho_{c} = K T e^{-r^{T}} N(d_{2}) & [\text{Rho for call options}] \\ &r ho_{p} = -K T e^{-r^{T}} N(-d_{2}) & [\text{Rho for put options}] \\ &v = S_{0} \sqrt{T} N'(d_{1}) e^{-q^{T}} & [\text{Vega}] \end{split}$$

Since a stock index can be treated as a security paying a known dividend yield, the previous equations can be used to value options on a index with, obviously,  $S_0$  the value of index,  $\sigma$  the volatility of the index and **q** the average annualized dividend yield on the index during the life of the option (the calculation of **q** should include only dividends the ex-dividend date of which occurs during the life of the option).

#### 1.1.2 Black-76

The Black-76 model was developed in 1976 to value European options on commodity futures. The prices for a futures option are given by the following formulas (refer to chapters 13 and 14 of: John C. Hull - Options, Futures, and Other Derivatives - (Fifth Edition), 2003):

$$c = e^{-rT} [F_0 N(d_1) - KN(d_2)]$$
$$p = e^{-rT} [KN(-d_2) - F_0 N(-d_1)]$$

With:

$$d_{1} = \frac{\ln\left(\frac{F_{0}}{K}\right) + \frac{1}{2}\sigma^{2}T}{\sigma\sqrt{T}}$$
$$d_{2} = \frac{\ln\left(\frac{F_{0}}{K}\right) - \frac{1}{2}\sigma^{2}T}{\sigma\sqrt{T}} = d_{1} - \sigma\sqrt{T}$$

where  $F_0$  is the futures price and  $\sigma$  is the volatility of the futures price.

Risk ratios or Greeks are:

$$\gamma = \frac{N'(d_1)e^{-rT}}{F_0\sigma\sqrt{T}}$$

 $\delta_c = e^{-rT} N(d_1)$ 

[Gamma]

[Delta for call options]

$\delta_p = e^{-rT} [N(d_1) - 1]$	[ <b>Delta</b> for put options]
$\theta_{c} = -\frac{F_{0}N'(d_{1})\sigma e^{-rT}}{2\sqrt{T}} + rF_{0}N(d_{1})e^{-rT} - rKe^{-rT}N(d_{2})$	[Theta for call options]
$\theta_{p} = -\frac{F_{0}N'(d_{1})\sigma e^{-rT}}{2\sqrt{T}} - rF_{0}N(-d_{1})e^{-rT} + rKe^{-rT}N(-d_{2})$	[ <b>Theta</b> for put options]
$rho_c = -cT$	[Rho for call options]
$rho_p = -pT$	[ <b>Rho</b> for put options]
$v = F_0 \sqrt{T} N'(d_1) e^{-rT}$	[Vega]

#### 1.1.3 Binary

Binary options are options with discontinuous payoffs. Cash-or-nothing options are a type of binary options: considering call options, they pay off nothing if the asset price ends up below the strike price at time T and pays a fixed amount (cash amount) if it ends up above the strike price (the contrary if the option is a put). The formulas to value cash-or-nothing options written on a stock providing a dividend yield at rate **q** are per unit of cash amount paid (refer to chapter 10 of: **Paul Wilmott - Quantitative Finance, 2001**):

 $c = e^{-rT} N(d_2)$ 

$$p = e^{-rT} N(-d_2)$$

with:

$$d_{1} = \frac{\ln\left(\frac{S_{0}}{K}\right) + \left(r - q + \frac{1}{2}\sigma^{2}\right)T}{\sigma\sqrt{T}}$$
$$d_{2} = \frac{\ln\left(\frac{S_{0}}{K}\right) + \left(r - q - \frac{1}{2}\sigma^{2}\right)T}{\sigma\sqrt{T}} = d_{1} - \sigma\sqrt{T}$$

Risk ratios or Greeks are:

$$\gamma_{c} = -\frac{e^{-rT}d_{1}N'(d_{2})}{\sigma^{2}S_{0}^{2}T}$$

[Gamma for call options]

 $\gamma_p = -\gamma_c$ 

[Gamma for put options]

 $\delta_c = \frac{e^{-rT} N'(d_2)}{\sigma S_0 \sqrt{T}}$ 

 $\delta_p = -\delta_c$ 

 $\theta_{c} = re^{-rT}N(d_{2}) + e^{-rT}N'(d_{2})\left(\frac{d_{1}}{2T} - \frac{r-q}{\sigma\sqrt{T}}\right)$  $\theta_{p} = re^{-rT}N(-d_{2}) - e^{-rT}N'(d_{2})\left(\frac{d_{1}}{2T} - \frac{r-q}{\sigma\sqrt{T}}\right)$ 

$$rho_{c} = -Te^{-rT}N(d_{2}) + \frac{\sqrt{T}}{\sigma}e^{-rT}N'(d_{2})$$
$$rho_{p} = -Te^{-rT}N(-d_{2}) - \frac{\sqrt{T}}{\sigma}e^{-rT}N'(d_{2})$$

 $v_{c} = -e^{-rT}N'(d_{2})\left(\sqrt{T} + \frac{d_{2}}{\sigma}\right)$  [Vega f  $v_{p} = -v_{c}$  [Vega

[Delta for call options]

[Delta for put options]

[Theta for call options]

[Theta for put options]

[Rho for call options]

[Rho for put options]

[Vega for call options]

[Vega for put options]

#### 1.1.4 Binomial

The Binomial Options Pricing Model (BOPM) for pricing American/European stock options involves constructing a binomial tree. This approach was described in an important paper by J. C. Cox, S. A. Ross and M. Rubinstein, "Option Pricing: A Simplified Approach" *Journal Of Financial Economics*, 7 (October 1979) 229-63. The BOPM method divides the life of an option into a large number of small time intervals and assumes that at each time interval the stock price (spot) follows a binomial process moving from its initial value  $S_0$  to one of two new values  $S_0 \mathbf{u}$  ("up" movement with probability  $\mathbf{p}$ ) and  $S_0 \mathbf{d}$  ("down" movement with probability  $\mathbf{1} - \mathbf{p}$ ) where  $\mathbf{u} > 1$  and  $\mathbf{d} < 1$ . Given this tree of stock prices, the option can be valued by working backwards from maturity (time T) (refer to chapters 10 and 18 of: John C. Hull - Options, Futures, and Other Derivatives - (Fifth Edition), 2003).

#### 1.1.5 Continuous Compounding

Theoretical prices and implied interest rate for forwards/futures, the underlying assets of which have known cash income (i.e. the asset will provide a perfectly predictable cash income, such as: stocks paying known dividends, coupon-bearing bonds, etc.) with a risk-free interest rate compounded continuously, are calculated as follows (refer to chapter 3 of: John C. Hull - Options, Futures, and Other Derivatives - (Fifth Edition), 2003 and chapter 6 of: Patrick Cusatis & Martin Thomas - Hedging Instruments & Risk Management, 2005):

 $F_0 = (S_0 - I) \cdot e^{rT}$ 

where:

Fo is the Forward/Futures price today

S<sub>0</sub> is the price of the asset underlying the forward/futures contract today

I is the present value of income

T is the time until delivery date in the forward/futures contract (in years)

 ${f r}$  is the risk-free interest rate per annum, expressed with continuous compounding, for an investment maturing at the delivery date (i.e., in T years).

Implied Interest Rate (IIR) is calculated as:

$$IIR = \frac{\ln\left(\frac{F_0}{S_0 - I}\right)}{T}$$

#### 1.1.6 Annual Compounding

Theoretical prices and implied interest rate for forwards/futures, the underlying assets of which have known cash income (i.e. the asset will provide a perfectly predictable cash income, such as: stocks paying known dividends, coupon-bearing bonds, etc.) with a risk-free interest rate compounded annually, are calculated as follows (refer to chapter 3 of: John C. Hull - Options, Futures, and Other Derivatives - (Fifth Edition), 2003 and chapter 6 of: Patrick Cusatis & Martin Thomas - Hedging Instruments & Risk Management, 2005):

$$F_0 = \left(S_0 - I\right) \cdot \left(1 + r\right)^T$$

where:

F<sub>0</sub> is the Forward/Futures price today

So is the price of the asset underlying the forward/futures contract today

I is the present value of income

T is the time until delivery date in the forward/futures contract (in years)

 $\mathbf{r}$  is the risk-free interest rate compounded annually for an investment maturing at the delivery date (i.e., in T years).

Implied Interest Rate (IIR) is calculated as:

$$IIR = \left(\frac{F_0}{S_0 - I}\right)^{\frac{1}{T}} - 1$$

## 1.2 Real-Time Calculations

Real-time market data of derivative instruments displayed in the **Price Info** and **Derivatives Price Info** windows can be enriched with some additional fields, namely:

ThPrice	Theoretical (fair) price	Futures/Options
ImplVol	Implied volatility	Options
ImplIntRate	Implied interest rate	Futures
Gamma	Gamma risk ratio	Options
Delta	Delta risk ratio	Options
Theta	Theta risk ratio	Options
Rho	Rho risk ratio	Options
Vega	Vega risk ratio	Options

calculated through several algorithms implemented in the BTS<sup>®</sup> financial library. In order to set up the parameters required for real-time calculations the following functions are provided via the **Pricing** menu of the top-level tool bar:

- Derivatives Settings
- Interest Rate

## 1.2.1 Derivatives Settings

Parameters required for real-time calculations can be set up by underlying instrument for all expiry dates or, possibly, for a selected one, covering futures and options in either case.

Derivatives Settings	6											
Market:	BIT   IDEM	<b>-</b> U	nderlying: FTMIB	-	Period:	2017/03			Add	🛛 🕌 Remo	ve 🛛 🚽 Save	
arket	Underlying		Period	AdjBid			AdjAsk		OverrideBig		OverrideAsk	_
IT   IDEM	FTMIB		2017/03									
options Futures												
	_											
Volatilities Details												
	Calls			Puts			Reset all v	olatilities				
ID	Bid	Ask	ID	Bid	Ask							
GENERAL	20		GENERAL		20	20		Calls		Puts		
MIB07C14250	20		MIB07014250		20	20						
MIB07C14500	20		MIB07014500		20	20 20 20 20	Bid	2		20 20	1	
MIBO7C14750	20	20	MIB07014750		20	20	Ask	2		20 🚔	3	
MIBO7C15000	20	20	MIB07015000		20	20						
MIB07C15250	20	20	MIB07015250		20	20			Apply			
MIB07C15500	20	20	MIB07015500		20	20						
MIB07C15750	20		MIB07015750		20	20						
MIBO7C16000	20		MIB07016000		20	20	Step volati	lities				
MIB07C16250	20		MIB07016250		20	20		All-	All+			
MIB07C16500	20		MIB07016500		20	20		All-				
MIBO7C16750	20		MIB07016750		20	20			Dute (			
MIB07C17000	20		MIB07017000		20	20			- Puts			
MIB07C17250	20		MIB07017250		20	20		Bid Ask	Bid As	sk.		
MIB07C17500	20	20	MIB07017500		20	20						
MIB07C17750	20		MIB07017750		20	20		- <b>-</b>	i iti	+		
	20		MIB07018000		20	20		Step:	0.01			
MIBO7C18000												

The first step of this process is the selection of an underlying instrument in a given market, possibly for a specific expiry date, which can be confirmed via the Add button and then saved with the Save button or, alternately, removed by pressing the Remove button.

Once an underlying instrument has been added to the top table of the **Derivatives Settings** window the following values can be assigned to it:

AdjBid	Adjustment to be applied to the bid price of an underlying instrument before calculating the price of any corresponding derivative instrument
AdjAsk	Adjustment to be applied to the ask price of an underlying instrument before calculating the price of any corresponding derivative instrument
OverrideBid	User-defined bid price to override the bid market price of the underlying instrument
OverrideAsk	User-defined bid price to override the ask market price of the underlying instrument

Two panes: **Options** and **Futures** are available, with the former including two sub-panes: **Volatilities** and **Details**.

The **Volatilities** sub-pane allows entering volatility values to be used in the calculation of theoretical (fair) prices for call and put options. Default values to be applied to all derivatives for the current underlying instrument must be assigned to the GENERAL entry, whereas different values can be entered for individual options. A set of commands at the right-hand side of this sub-pane provides a quick way to assign and/or modify volatility values by instrument, option type or side (bid or ask).

Options Futures Volatilities Details								
	Calls			Puts			Reset all volatilities	
ID	Bid	Ask	ID	Bid	Ask			
GENERAL	20	20	GENERAL	20	20	1	Calls	Puts
MIB07C14250	20	20	MIB07014250	20	20 20 20		Bid 20 🚍	00
MIBO7C14500	20	20	MIBO7014500	20	20			20
MIBO7C14750	20	20	MIBO7014750	20	20		Ask 20	20
MIB07C15000	20	20	MIBO7015000	20	20 20		Apply	
MIBO7C15250	20	20	MIBO7015250	20	20	F	Apply	
MIBO7C15500	20	20	MIBO7015500	20	20			
MIB07C15750	20	20	MIBO7015750	20	20		C4	
MIBO7C16000	20	20	MIBO7O16000	20	20 20		Step volatilities	
MIBO7C16250	20	20	MIBO7016250	20	20	М	All- All+	
MIBO7C16500	20	20	MIBO7O16500	20	20			
MIBO7C16750	20	20	MIBO7016750	20	20	TI	- Calls + - Puts	+
MIBO7C17000	20		MIB07017000	20	20	TI		
MIBO7C17250	20	20	MIB07017250	20	20	TI	Bid Ask Bid As	sk
MIBO7C17500	20		MIB07017500	20	20	TI		
MIB07C17750	20		MIB07017750	20	20	TI		
MIBO7C18000	20	20	MIBO7O18000	20	20	Ц	Step: 0.01	
MIRO7C18250	20	20	MIRO7018250	20	20			

The **Details** sub-pane is used to select the algorithm to be applied by the Pricing Service in order to calculate real-time data of all options for the current underlying instrument and enter all the input values required by the specific algorithm.

Options Futures									
Volatilities De	tails								
Calls					Puts				
Algorithm:	Black And Scholes	Di	ividend		Algorithm:	Black And Scholes	Divide	end	الجمعيم
ULMarket	BIT   INDICES		Date	Amount	ULMarket	BIT   INDICES		Date	Amount
Day Counting:	E30/360	•			Day Counting:	E30/360			
ULPrice Type	Last				ULPrice Type	Last			
Price Type	Bid\Ask				Price Type	Bid\Ask			
Bin. Time Divisio	n:	30			Bin. Time Division		30		
Cash Amount:		1			Cash Amount:		1		
Yield (%):		÷		Clear	Yield (%):		-		Clear

Here follows a brief description of all the fields displayed in the **Details** sub-pane:

Algorithm	Algorithms to be used for real-time calculation of theoretical price, implied volatility and <i>Greeks</i> for options:
	- Black And Scholes
	- Black 76
	- Binomial AM
	- Binomial EU
	- Binary
ULMarket	Market or data vendor whose price feed is to be used for the underlying instrument
Day Counting	Day counting method:
	- ACT/365
	- E30/360
ULPrice Type	Type of spot price of the underlying instrument from market or data vendor feed to be used in calculating theoretical price and <i>Greeks</i> for options or theoretical price for forwards/futures contracts:
	- Bid/Ask
	- Last
	- Bid
	- Ask
	- Mid
Price Type	Type of price of the derivative instrument from market or data vendor feed

	to be used in calculating its implied volatility for options or implied interest rate for forwards/futures contracts: - Bid/Ask - Last - Bid - Ask - Mid
Bin. Time Division	Number of steps to be performed in the Binomial AM and Binomial EU algorithms
Cash Amount	Cash amount paid if the spot price ends up above (below) the strike price for a call (put) option
Yield (%)	Dividend yield
Dividends	Dates and amounts of future payments (discrete dividends)

Each algorithm requires a specific set of input values as shown in the following table:

Algorithm	Black And Scholes	Black 76	Binomial AM	Binomial EU	Binary
ULMarket	Х	Х	Х	Х	Х
Day Counting	Х	Х	Х	Х	Х
ULPrice Type	Х	Х	Х	Х	Х
Price Type	Х	Х	Х	Х	Х
Bin. Time Division			Х	Х	
Cash Amount					Х
Yield (%)	X		Х	Х	Х
Dividends	Х		Х		

Parameter values defined for call an/or put options can be removed via the Clear button.

The **Futures** pane is used to select the algorithm to be applied by the Pricing Service in order to calculate real-time data of all futures for the current underlying instrument and enter all the input values required by the specific algorithm.

Options	Futures	<u> </u>		
Algorithm:	Continuous Compounding	Dividend		7
ULMarket	·	Dato	Amount	
Day Count	ing: <mark>E30/360 🔤</mark>			
ULPrice Ty	ype Last			
Price Type	Bid\Ask	j i	Clear	

Here follows a brief description of all the fields displayed in the **Futures** pane:

Algorithm	Algorithm to be used for real-time calculation of theoretical price and implied interest rate for forwards/futures contracts:
	- Continuous Compounding
	- Annual Compounding
ULMarket	Market or data vendor the price feed of which is to be used for the underlying instrument
Day Counting	Day counting method:
	- ACT/365
	- E30/360
ULPrice Type	Type of spot price of the underlying instrument from market or data vendor feed to be used in calculating theoretical price for forwards/futures contracts: - <b>Bid/Ask</b>
	- Last
	- Bid
	- Ask
	- Mid
Price Type	Type of price of the derivative instrument from market or data vendor feed to be used in calculating its implied interest rate for forwards/futures contracts: - <b>Bid/Ask</b>
	- Last
	- Bid
	- Ask
	- Mid
Dividends	Dates and amounts of future payments (discrete dividends)

Each algorithm requires a specific set of input values as shown in the following table:

Algorithm	Continuous Compounding	Annual Compounding		
ULMarket	Х	Х		
Day Counting	X	Х		
ULPrice Type	Х	Х		
Price Type	Х	Х		
Dividends	Х	Х		

Parameter values defined for futures can be removed via the **Clear** button.

#### 1.2.2 Interest Rate Curve

All the algorithms used in real-time calculations require interest rate curves to be defined for the currencies that derivative instruments are traded in. After selecting a currency by clicking on the corresponding pane tab, users have two options to enter discrete values for interest rate curves:

- double-click a date in the Calendar toolbox and then enter the corresponding rate in the Interest Rate field. The value can be set or adjusted via the arrows buttons. In order to confirm the new date-rate pair the Add button must be clicked;
- 2) double-click the desired value for a given date directly in the chart pane. This will create a new point in the interest rate curve.

The so defined parameters will be graphically displayed in the chart pane of the Interest Rate window

	erest Rate:	O.7 CLF C		idate	Remove CRC		1	Coom Ou		is movemen	GBX	GHS	HKD
CAD	CHF	CLF C	LP CNY	СОР	CRC	СZК Г	DEM D	КК ЕGР	EUR	GBP	GBX	GHS	HKD
	7/03/13	17/03/20	017/03/27	017/04/03	2017/04/10	2017/04/17	2017/04/24	2017/05/01	2017/05/08	2017/05/15	2017/05/22	2017/05/29	2017/06/05
	7/03/06	17/03/06	17/03/16 117/03/13	017/03/06 017/03/13 017/03/20	2017/03/06 2017/03/20 2017/03/27	2017/03/13 2017/03/13 2017/03/23 2017/04/03 2017/04/10	2017/03/13 2017/03/13 2017/03/27 2017/04/10 2017/04/10	2017/03/03/03 2017/03/23 2017/03/20 2017/04/03 2017/04/17 2017/04/12	2017/03/13 2017/03/23 2017/03/20 2017/04/10 2017/04/10 2017/04/12 2017/04/12			2017/03/13 2017/03/20 2017/03/20 2017/04/10 2017/04/10 2017/04/10 2017/05/08 2017/05/15 2017/05/15 2017/05/15 2017/05/15	

Previously-defined curve values can be subsequently modified by using one of the following three options:

- select the desired curve node within the chart pane then enter a new value in the Interest Rate field or update the current one via the arrow buttons and finally press the Update button;
- 2) left-click a curve node related to a specific date within the chart pane and drag it along the y-axis to modify its value. By doing so the user can simultaneously change all the values related to dates placed on the right-side of the selected one, also including this one, by simply moving the selected node on its y-axis. Just in case only a single value

related to a specific date needs to be modified (increased or decreased), the user must left-click the desired node and simultaneously press the **Ctrl** key;

3) double-click above or below a specific curve node within the chart pane, along the **y**-**axis**, to increase or decrease its value.

The X-axis movements locked option box placed in the Interest Rate window tool bar is checked by default, allowing users to drag curve nodes only in the interest rate direction. On the contrary, if the X-axis movements locked option box is unchecked, users can drag the curve nodes also in the date direction.

To delete an existing value the user must select the related curve node and then click the Remove button. This procedure has to be repeated for each curve node to be removed.

By default, the curve display area covers a one-month time interval. This time range can be increased by clicking the Zoom Out button, or it can be reduced by clicking the Zoom In button.

The parameters of each single curve related to a specific currency defined and/or modified by the user can be saved in the application database by clicking the Save button. At the end of each trading day all existing curves are moved forward in time by one day.

## 1.2.3 Options Calculator

The **Options Calculator** window can be used for one-off calculation of theoretical price, risk ratios or **Greeks** and implied volatility for any individual option: theoretical prices will always be calculated using **Black-Scholes**, **Black 76** and **Binomial AM** algorithms. It is possible to activate this functionality via the **Market Information** menu of the **BIT Trading Station** platform top-level tool bar by clicking the **Options Calculator** option.

Business Date: 2017/03/03							Call		Put		
Strike Date: 2017/06/16		Date	Amount			B/S	B76	Bin	B/S	B76	Bin
Interest (%):	3	<u>- + 2017/06/30</u>		0.5	Price	1.875420	1.691740	1.866920	1.533556	1.691740	1.555054
		- + 2017/12/29		0.5	Impl Vol	0.392083	0.414426	0.394059	0.432583	0.414426	0.431299
Volatility (%):	20				Delta	0.5531894	0.5168734	0.5529260	-0.4468106	-0.4745800	-0.458245
Market Price:	3.5				Gamma	0.0923995	0.0923004	0.0938342	0.0923995	0.0923004	0.0975653
		Day Counting: E30/3			Vega	0.0845969	0.0845062	0.0841818	0.0845969	0.0845062	0.0840621
UL Value:			160		Theta	-0.0097653	-0.0079530	-0.0098913	-0.0065058	-0.0079530	-0.0069191
Strike Price:	40 🚔 E	Bin. Time Division:		50	Rho	0.0579437	-0.0048403	0.0584559	-0.0555227	-0.0048403	-0.0431041
			Clear								

Here follows the list of values to be entered by the user:

Business Date	Business date
Strike Date	Strike (expiration) date
Interest (%)	Risk-free interest rate to be used in the calculation of theoretical price and <i>Greeks</i>
Volatility (%)	Volatility of the underlying instrument to be used in the calculation of

	theoretical price and Greeks							
Market Price	Market price of the derivative instrument to be used in calculating its implied volatility							
UL Value	Spot price of the underlying instrument							
Strike Price	Strike price							
Dividends	Dates and amounts of future payments (discrete dividends)							
Day Counting	Day counting method:							
	- ACT/365							
- E30/360								
Bin. Time Division	Number of steps to be performed in the Binomial AM and Binomial EU algorithms							

Calculated values will be displayed in the right-hand table of the window after pressing the **Calculate** button. Moreover, a new set of values can be entered after pressing the **Clear** button.

#### 2.0 Derivatives Price Info

The **Derivatives Price Info** window, as opposed to the **Price Info** one, gives a more compact view of all the derivative instruments linked to the same underlying instrument or index. A tray can be created in the **Derivatives Price Info** window for one underlying instrument, which will contain three panes: **Underlying**, **Futures** and **Options**.

**Futures** and **Options** panes can be re-sized or moved inside the tray related to an underlying instrument, whereas the fields related to the underlying instrument are locked in the top part of the tray.

Several trays can be opened inside the same **Derivatives Price Info** window for different underlying instruments.

The **Derivatives Price Info** window can be opened by selecting the corresponding command in the **Market Information** menu.

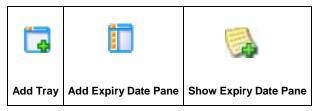
#### 2.1 Menu Bar

A cascading menu appears by clicking the Configuration menu. This menu shows the following commands:

- Configuration
  - Add Tray
  - Add Expiry Date Pane
  - Show Expiry Date Pane
  - Toogle View [ Ctrl-W ]

#### 2.2 Tool Bar

The **Derivatives Price Info** window tool bar is located under the menu bar. It gives quick access to the most frequently used commands, which are mapped to specific buttons. Each command can be activated by clicking the corresponding button.



#### 2.3 Underlying Pane

The **Underlying** pane displays real-time data in a single scrollable row for the selected underlying instrument or index.

Instr	Instrument description
Symbol	Common «human understood» representation of instrument or index
ISIN	Instrument ISIN code
Mkt	Market code
BidSz	Displayed size of best buy price
Bid	Best buy price
Ask	Best sell price
AskSz	Displayed size of best sell price
Last	Most recent trade price for instrument or more recent value for index
Var	Difference between last trade price and previous day's close
LastSz	Size of the most recent trade
LastTime	Time of the most recent trade
TotVol	Cumulative size of all trades
TotAmt	Cumulative amount of all trades
High	Highest price at which instrument traded or highest value of index
Low	Lowest price at which instrument traded or lowest value of index
Open	Opening price of instrument or opening value of index
Close	Closing price of instrument or closing value of index

Here follows a brief description of all the columns making up the **Underlying** pane:

#### 2.4 Futures Pane

The **Futures** pane displays real-time data for all the futures on the current underlying instrument the user can sort by every column clicking on them. Fields shown in **blue** are calculated by the **Pricing Service**.

Here follows a brief description of all the columns making up the **Futures** pane:

Instr	Futures contract description
Symbol	Common «human understood» representation of futures contract
ISIN	ISIN code of futures contract
Mkt	Market code
ImpIntB	Implied interest rate related to the best bid price of futures contract
BidSz	Displayed size or best bid price

Bid	Best bid price
Ask	Best ask price
AskSz	Displayed size of best ask price
ImpIntA	Implied interest rate related to the best ask price of futures contract
Last	Most recent trade price of futures contract
Var	Difference between last trade price and previous day's close
LastSz	Size of the most recent trade
LastTime	Time of the most recent trade
TotVol	Cumulative size of all trades
TotAmt	Cumulative amount of all trades
High	Highest price at which futures contract traded
Low	Lowest price at which futures contract traded
Open	Opening price of futures contract
Close	Closing price of futures contract

#### 2.5 **Options Panes**

The **Options panes** display real-time data for all the call and put options on the current underlying instrument. Columns are grouped in 3 sets, the first one for call options, the second one for put options and the third one for calculations with the possibility to move columns within each group. More **Options** panes can be created for the same underlying instrument or index, one per expiry date or one for all expire dates ("All" pane). **Blue** fields are calculated by the **Pricing Service**, whereas **red** fields are entry fields.

Here follows a brief description of all the columns making up the **Call**, **Put** and **Calculations** sub-panes of the **Options** pane.

	OPTIONS PANE								
Strike	Strike price of an option								
ExpDate	Expiration date of an option								
	CALL OPTIONS SUBPANE								
Instr	Call option description								
Symbol	Common «human understood» representation of call option								
ISIN	ISIN code of call option								
Mkt	Market code								
GammaB	Gamma related to the theoretical bid price								
DeltaB	Delta related to the theoretical bid price								
RhoB	Rho related to the theoretical bid price								
ThetaB	Theta related to the theoretical bid price								
VegaB	Vega related to the theoretical bid price								
ImpVoIB	Implied volatility related to the best bid price of call option								
BidSz	Displayed size or best bid price								

Bid	Best bid price
Ask	Best ask price
AskSz	Displayed size or best ask price
ImpVoIA	Implied volatility related to the best ask price of call option
GammaA	Gamma related to the theoretical ask price
DeltaA	Delta related to the theoretical ask price
RhoA	Rho related to the theoretical ask price
ThetaA	Theta related to the theoretical ask price
VegaA	Vega related to the theoretical ask price
SynthBid	Synthetic short stock price (see below)
Last	Most recent trade price of call option
Var	Difference between last trade price and previous day's close
LastSz	Size of the most recent trade
LastTime	Time of the most recent trade
TotVol	Cumulative size of all trades
TotAmt	Cumulative amount of all trades
High	Highest price at which call option traded
Low	Lowest price at which call option traded
Open	Opening price of call option
Close	Closing price of call option
	PUT OPTIONS SUBPANE
Instr	Put option description
Symbol	Common «human understood» representation of put option
ISIN	ISIN code of put option
Mkt	Market code
SynthAsk	Synthetic long stock price (see below)
GammaB	Delta related to the theoretical bid price
DeltaB	Rho related to the theoretical bid price
RhoB	Theta related to the theoretical bid price
ThetaB	Vega related to the theoretical bid price
VegaB	Implied volatility related to the best bid price of put option
ImpVoIB	Implied volatility related to the best bid price of put option
BidSz	Displayed size or best buy price
Bid	Best bid price
Ask	Best ask price
AskSz	Displayed size or best sell price
ImpVoIA	Implied volatility related to the best ask price of put option
GammaB	Gamma related to the theoretical ask price
DeltaA	Delta related to the theoretical ask price

RhoA	Rho related to the theoretical ask price						
ThetaA	Theta related to the theoretical ask price						
VegaA	Vega related to the theoretical ask price						
Last	Most recent trade price of put option						
Var	Difference between last trade price and previous day's close						
LastSz	Size of the most recent trade						
LastTime	Time of the most recent trade						
TotVol	Cumulative size of all trades						
TotAmt	Cumulative amount of all trades						
High	Highest price at which put option traded						
Low	Lowest price at which put option traded						
Open	Opening price of put option						
Close	Closing price of put option						
	CALCULATIONS SUBPANE						
CallBid	Call option bid price entered by the user						
CallImpVoIB	Implied volatility related to manual bid price of call option calculated by the Pricing System						
CallAsk	Call option ask price entered by the user						
CallImpVoIA	Implied volatility related to manual ask price of call option calculated by the Pricing System						
PutBid	Put option bid price entered by the user						
PutImpVoIB	Implied volatility related to manual bid price of put option calculated by the Pricing System						
PutAsk	Put option ask price entered by the user						
PutImpVoIA	Implied volatility related to manual ask price of put option calculated by the Pricing System						

Calculated field values (shown in **blue**) are generated and notified in real-time mode by the **Pricing Service**, which will use parameters values set via the **Derivatives Settings** command in the **Pricing** menu.

As regards the two values: **SynthBid** (Synthetic Bid Price) and **SynthAsk** (Synthetic Ask Price) they are calculated by the GUI client using the following formulas:

- SynthBid = Strike + CallBid PutAsk (both premiums for the same strike price) [synthetic short stock]
- SynthAsk = Strike + CallAsk PutBid (both premiums for the same strike price) [synthetic long stock]

#### 2.6 Select a new underlying instrument/index

It is possible to create a tray for an underlying instrument by selecting the **Add Tray** command in the **Configuration menu** of the **Derivatives Price Info.** 

Via the **Ctrl+LeftMouseClick** command on the empty tab of a tray **underlying instrument or index** via a **combo-box** (populated by collecting all the entries in the markets assigned to this tool with a non-null underlying field) or, alternately, in a **free-text** format can be selected

2	2	Derivati	ves Price II	nfo Co	nfigur	ation Ord	ers							
	FTM													
	FTN ∎	IIB (BIT	INDICES]	1911	J <b></b>	Bid		A	Ask	La	V	Last	LastTi	Tot
	⊢													

#### 2.7 Adding options by expiry date

Once the underlying instrument or index has been selected, the three above-mentioned panes will be displayed: the **Underlying** and **Futures** panes will be already receiving real-time data from the corresponding markets, whereas one or more expiry dates are to be picked up from a selection list.

🏴 MAR 17 🗕 🗙				
Instr	OpenInterest	TradingPhase	The	oPriceB
MIB07C14250	Ontiona Evning		70.332020	
MIBO7C14500	Options Expiry [	Jale - FTMIB	×	20.368237
MIBO7C14750			All	0.404685
MIBO7C15000	All			20.442414
MIBO7C15250	JUN 17		Invert	70.486196
MIBO7C15500	SEP 17			20.554524
MIBO7C15750	DEC 17		Clear	70.708976
MIB07C16000	JUN 18			21.126446
MIBO7C16250	DEC 18			2.247358
MIBO7C16500	JUN 19		-	25.025311
MIBO7C16750				81.259974
MIB07C17000	Ok	3.913514		
MIB07C17250		communato ara		17.228995
MIB07C17500	615	Continuous tra	ding 8	06.458446

+

The **All** button allows the selection of all the expiry dates in the selection list, thus creating one pane per date, whereas the **All** option in the selection list creates a single pane for all expiry dates.

(BIT   INDICE	5] _ ×																				
	ast	High Low																			
FTSEMIB	18198.18	18280.88 1	8099.01																		
utures																					
tr Oper	Int Tradin	Dhaso Ev	pDate	TheoPriceB	ImpintE	Bid	Bid As	sk Ask	Sz Impin	TheoPri	· 1:	ıst	Las	stSz T	otVol Hi	ah Low	Open	LastTime		1	
37C 5371		uous trading								563 18153.1				1			75 18,775		34:51.624000		
UR 17 _ x																					
														Call							
tr	OpenInteres			TheoPriceB	GammaB	DeltaB	RhoB	ThetaB	VegaB	ImpVolB	BidSz	Bid	Ask	AskSz		GammaA	DeltaA	RhoA	ThetaA	VegaA	TheoPriceA
BO7C15000		Continuous t		3152.673259					0 0.0027241	N/A									-0.1140780		
BO7C15250		Continuous t		2902.720108					3 0.0114675	N/A						0.0000003					2902.7201
BO7C15500		Continuous t		2652.800193					3 0.0415653	N/A							0.9997317				
BO7C15750 BO7C16000		Continuous t		2402.993666 2153.523988					8 0.1306018 1 0.3580205	N/A N/A						0.0000038					
307C16000 307C16250		Continuous t		2153.523988					1 0.3580205 7 0.8614625	N/A						0.0000103					
BO7C16200		Continuous t		1658.348772					0.8014025	N/A						0.0000248					1658.3487
307C16750		Continuous t		1415.851685					1 3.4498925	N/A						0.0000920					
307C17000		Continuous t		1180,745835					9 5.8025675	N/A					N/A	0.0001669	0.9266591	8.2536947			1180,7458
307C17250		Continuous t	rading	957.606332	0.0002516	0.8715229	7.8432898	4.653413	5 8,7492261	0.223947	80	980	995	90	0.223947	0.0002516	0.8715229	7.8432898	-4.6534135	8,7492261	957,6063
BO7C17500	615	Continuous t	rading	751.881558	0.0003417	0.7940228	3 7.2094603	-6.270083	9 11.88094	0.180960	65		730	25	0.180960	0.0003417	0.7940228	7.2094603	-6.2700839	11.88094	751.8815
BO7C17750		Continuous t		569.035237	0.0004197				6 14.59345		90	480	486	60	0.135474	0.0004197			-7.6661156	14.59345	569.0352
BO7C18000		Continuous t		413.433559					0 16.28129						0.105581	0.0004682					
BO7C18250		Continuous t		287.364193					4 16.56348		70				0.084641						
BO7C18500		Continuous t		190.534498					0 15.42299				22	40	0.073091						
307C18750 307C19000		Continuous t Continuous t		120.243004 72.110589			2 2.3112528		8 13.19118 6 10.39837	N/A N/A						0.0003793 0.0002990		2.3112528	-6.8805208 -5.4199736		120.2430 72.1105
BO7C19000 BO7C19250		Continuous t		41.053532					4 7.5789964	N/A						0.0002990					41.0535
BO7C19250		Continuous t		22,175961			0.5862901		5 5.1233593	N/A						0.0001473					22,1759
BO7C19750		Continuous t		11.364147					0 3.2215463	N/A						0.0000926					
BO7C20000		Continuous t		5.525852	0.0000543	0.018500	3 0.1743057	-0.983341	4 1.8895187	N/A					N/A	0.0000543	0.0185003	0.1743057	-0.9833414	1.8895187	
BO7C20250		Continuous t	rading	2.550773	0.0000298	0.0092334	0.0871041	-0.539294	7 1.0365030	N/A					N/A	0.0000298	0.0092334	0.0871041	-0.5392947	1.0365030	2.5507
INTERNERA		ه حسبت الفسيح ا		4 440597	0.0000463		0.0444950	0.077004	0.0004000	11/4					81/4	0.0000453	0.0043650	0.0444350	0.0770040	0.5334300	4 4400
rategies _																					
rategies -					1 T							_									
Legs		dingPhase	BidSz	Bid	Ask	AskSz L	ast L	astSz	LastTime												
7FT (B 1) I		itinuous trading																			
(\$ 1)	IB/C																				
7 (B 1) F		tinuous trading																			
(S 1)	HB7I	anacacation																			
7IT (B 1) F		tinuous trading																			
(S 1) F	IB7F																				

Options panes for different expiry dates can be added to the current tray in two different ways:

- by selecting the Show Expiry Date Pane command in the Configuration menu or by right-clicking one of the existing Options pane tabs and then running the Show Expiry Date Pane command. A multiple selection list will pop up with the remaining expiry dates which the user can select to open one or more option panes
- by selecting the Add Expiry Date Pane command in the Configuration menu or by right-clicking one of the existing Options pane tabs and then running the Add Expiry Date Pane command. One pane will be added to the existing ones and the user can assign an expiry date to it by executing the Ctrl+LeftMouseClick command on the corresponding tab and then entering a date in the 'MON YY' format (e.g. 'JUN 17'). The user can also enter the '\*' character to display a single selection list with the remaining expiry dates to choose from.

It is also possible to change the expiry date of an existing **Options** pane by executing the **Ctrl+LeftMouseClick** command on the corresponding tab or via the **Modify Expiry Date** command in the right-click pop-up menu and then entering a date in the '**MON YY**' format (e.g. 'JUN 17'). The user can also enter the '\*' character to display a single selection list with the remaining expiry dates to choose from.

#### 2.8 Embedded Order/Price Depth

An embedded **Order/Price Depth** window can pop-up for each derivative instrument or instrument couple in the **Futures** or **Options** pane by right-clicking on the corresponding row and then selecting the **Order/Price Depth** command or double clicking on:

Futures pane: Instr, Symbol, ISIN and Mkt columns. Options pane: Instr, Symbol, ISIN, Mkt, Strike and ExpDate column



By double clicking on one of the above-mentioned fields of the expanded book it will disappear.

#### Disclaimer

document contains text, This data, illustrations, graphics, photographs, artwork, names, logos, trade marks, service marks and information ("Information") connected with Borsa Italiana S.p.A. ("Borsa Italiana"). Borsa Italiana attempts to ensure Information is accurate, however Information is provided "AS IS" and on an "AS AVAILABLE" basis and may not be accurate or up to date. Information in this document may or may not have been prepared by Borsa Italiana and in this last case is made available without responsibility on the part of Borsa Italiana.

The publication of this document does not represent solicitation, by Borsa Italiana, of public saving and is not to be considered as a recommendation by Borsa Italiana as to the suitability of the investment, if any, herein described.

#### **Contact Details**

Borsa Italiana Clients Technology Service Team

#### **Technical Account Management Italy**

clients-services@borsaitaliana.it +39 02 72426348/606/647

#### Service Desk Italy

service-desk@borsaitaliana.it Toll Free: 0080026772000 From mobile: +39 02 45411399

