# Credit Value Adjustments

## Credit Value Adjustments

"Credit Value-at-Risk (CVaR) is a measure of risk resulting from the possibility that a counterparty might not be able to honor its obligations" – Yves Hilpisch.

"Credit valuation adjustment (CVA) is the difference between the risk-free portfolio value and the true portfolio value that takes into account the possibility of a counterparty default. In other words, CVA is the market value of counterparty credit risk" – Wikipedia definition of CVA.

"CVA is derived from the CVaR" – Yves Hilpisch.

The default of large corporations in the past 30 years proved that no investors are immune from credit risk. The 2007/2008 global liquidity crisis showed that the default risk is even higher during periods of significant turmoil. Therefore, financial institutions invested heavily in developing new tools for credit risk analysis and forecasting.

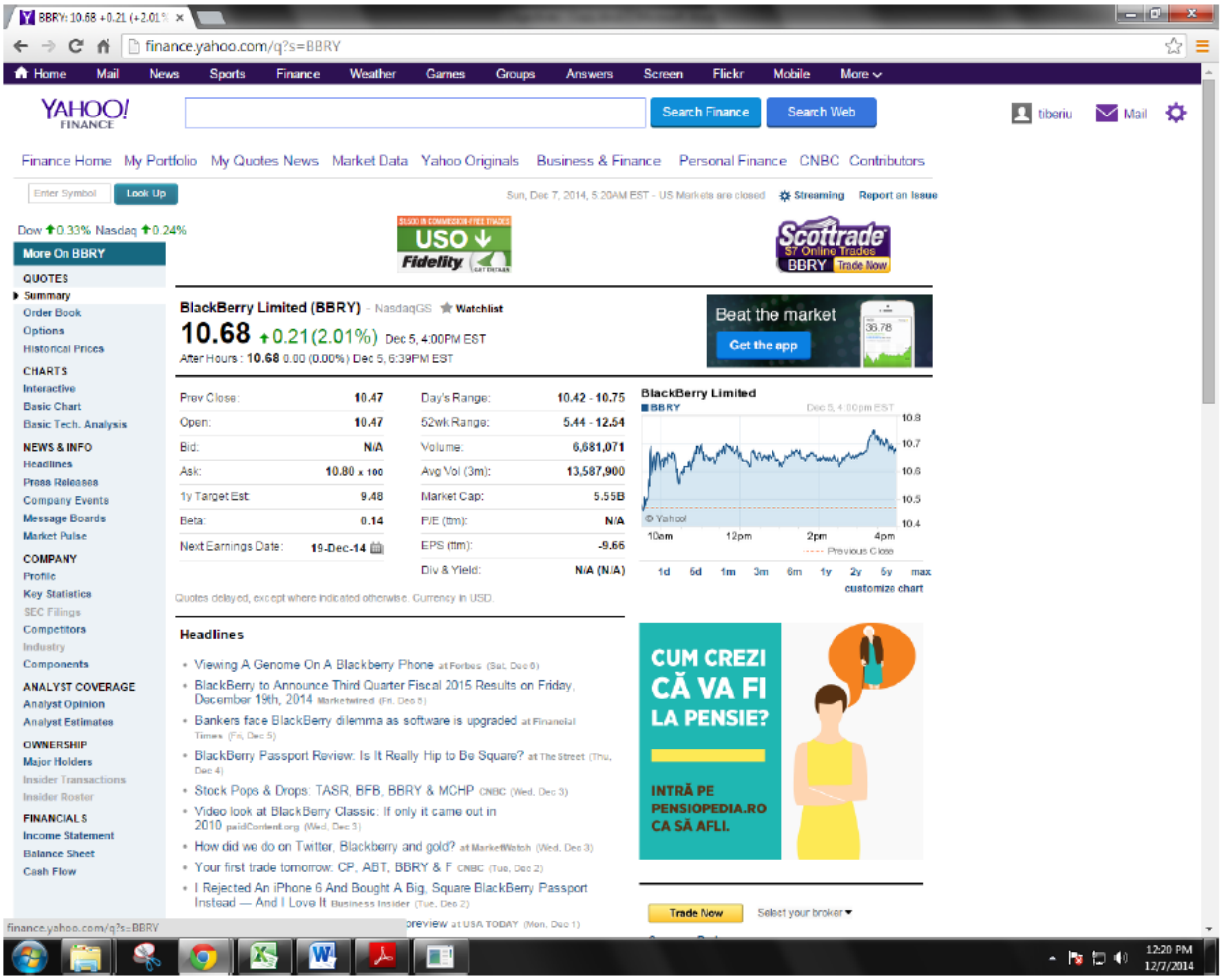
Companies started to calculate the Counterparty Credit Risk (CCR) to incorporate into derivatives' prices. Therefore, CVA emerged as a useful tool in credit risk analysis.

CVA in practice:

- CVA is the price one would pay to hedge the portfolio of derivative instruments against counterparty credit risk.
- CVA was introduced in 2007/2008 in order to enhance fair value accounting.
- CVA is largely used in the derivatives markets.
- There is not a standardized methodology for CVA as financial companies use different versions of CVA depending on their needs and complexity required.
- Complex CVA approaches require market risk factor simulations and different market scenarios.
- Large financial institutions that have a high share of derivatives in their portfolio invest heavily in CVA analysis and even have a separate CVA trading desk.
- Investment banks have a CVA desk that carries out the following tasks:
  - hedge for possible losses due to counterparty default
  - hedge to reduce the amount of capital required under the CVA calculation of Basel 3

## Example

We have one BlackBerry stock in our portfolio. The stock price on Friday the 5th of December was 10.68 USD (from Yahoo Finance as showed below). We want to calculate CVaR and CVA for this portfolio. We use Python in our analysis. The Python was provided by Yves Hilpisch.



Import Python modules:

```
>>> import numpy as np
>>> import numpy.random as npr
>>> from pylab import *
>>> import matplotlib.pyplot as plt
```

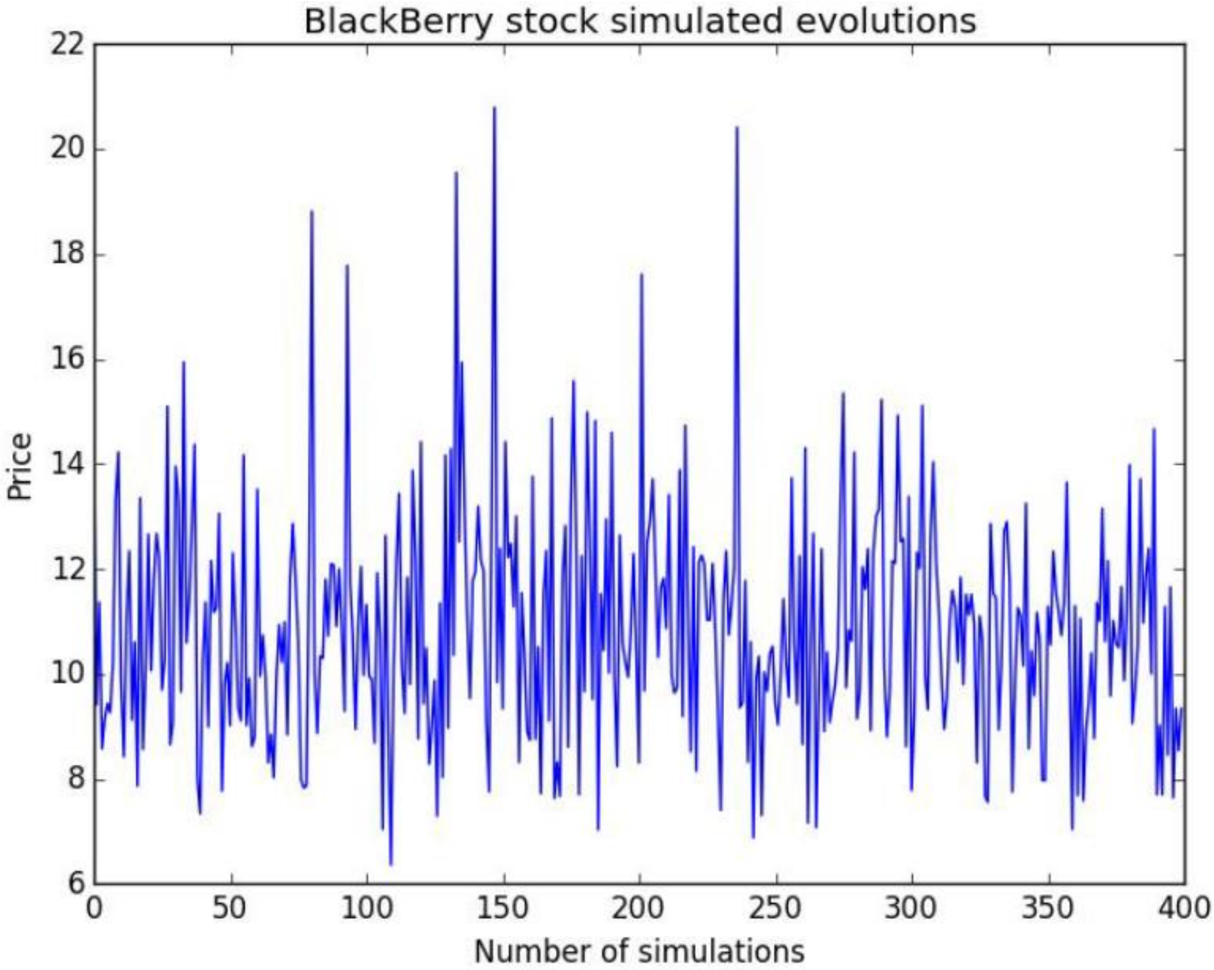
Consider the Black–Scholes–Merton model with the following parameters:

Stock price evolution is considered to follow a Geometric Brownian Motion:

```
>>> S0 = 10.68
>>> r = 0.01
>>> sigma = 0.2
>>> T = 1.
>>> I=400
>>> ST = S0 * np.exp((r - 0.5 * sigma ** 2) * T+ sigma * np.sqrt(T) * npr.standard_normal(I))
```

We simulate BlackBerry stock price movements:

```
>>> ST
array([ 14.1387732 ,   9.41168492,  11.36166677,   8.57137813,
         9.13998706,   9.43323287,   9.26017231,  10.21358981,
        13.34773552,  14.22240156,   9.83174466,   8.41898195,
        11.04158642,  12.33915473,   9.11802004,  10.60138712,
         7.85924642,  13.35095331,   8.55966359,  10.0508237 ,
        12.65583934,  10.06376275,  11.76174893,  12.66927371,
        12.19785931,   9.69180567,  10.25353543,  15.09600627,
         8.64751427,   9.08014664,  13.95235702,  13.33678755,
         9.65563377,  15.9380399 ,  10.59028498,  11.42548846,
        12.94248259,  14.36793257,   7.98707786,   7.33468041,
```




```
>>> L=0.05 #fixed (average) loss level
>>> p=0.01 #probability for default
>>>
```

Generate default scenarios using Poisson distribution:

```
>>> D = npr.poisson(p * T, I)
>>> D = np.where(D > 1, 1, D)
```

Poisson distribution is used in modeling rare events, in our case, if the counterparty goes bankrupt.

Risk-neutral value of the future index level is equal to the current value of the asset today if there is no default.

Risk-neutral value:

```
>>> np.exp(-r * T) * 1 / I * np.sum(ST)
10.780069055602915
```

CvaR:

```
>>> CVaR = np.exp(-r * T) * 1 / I * np.sum(L * D * ST)
>>> CVaR
0.0042798199945273648
```

Present value of the asset adjusted for the credit risk:

```
>>> S0_CVA = np.exp(-r * T) * 1 / I * np.sum((1 - L * D) * ST)
>>> S0_CVA
10.775789235608386
```

CVaR can also be calculated as follows:

CVaR = risk-free value – risk-adjusted value

Another way for calculating the present value of the asset:

```
>>> S0_adj = S0 - CVaR
>>> S0_adj
10.675720180005472
```

Calculate the number of possible losses:

```
>>> np.count_nonzero(L * D * ST)
3
```

We observe only 3 losses due to credit risk given a number of 400 simulations and 1% assumed default probability.

The three possible losses:

```
>>> L*D*ST
array([ 0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.71112008,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
```

```
        0.        ,  0.        ,  0.        ,  0.        ,  0.
        0.        ,  0.        ,  0.        ,  0.        ,  0.
        0.        ,  0.        ,  0.        ,  0.        ,  0.
        0.        ,  0.        ,  0.        ,  0.        ,  0.
        0.        ,  0.        ,  0.        ,  0.        ,  0.
        0.        ,  0.        ,  0.        ,  0.40135781,  0.
```

```
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.61665528,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ,
        0.        ,  0.        ,  0.        ,  0.        ,  0.        ])
```

The three losses incurred by the financial institution are: 0.71112008, 0.40135781 and 0.61665528.

The fixed average loss level is 0.50.

Below is a graph of losses due to risk-neutrally expected default (stock). According to the graph there are 3 losses in 400 simulations and a 1% probability of default.