Unilateral CVA Calculation

Financial Engineering Project

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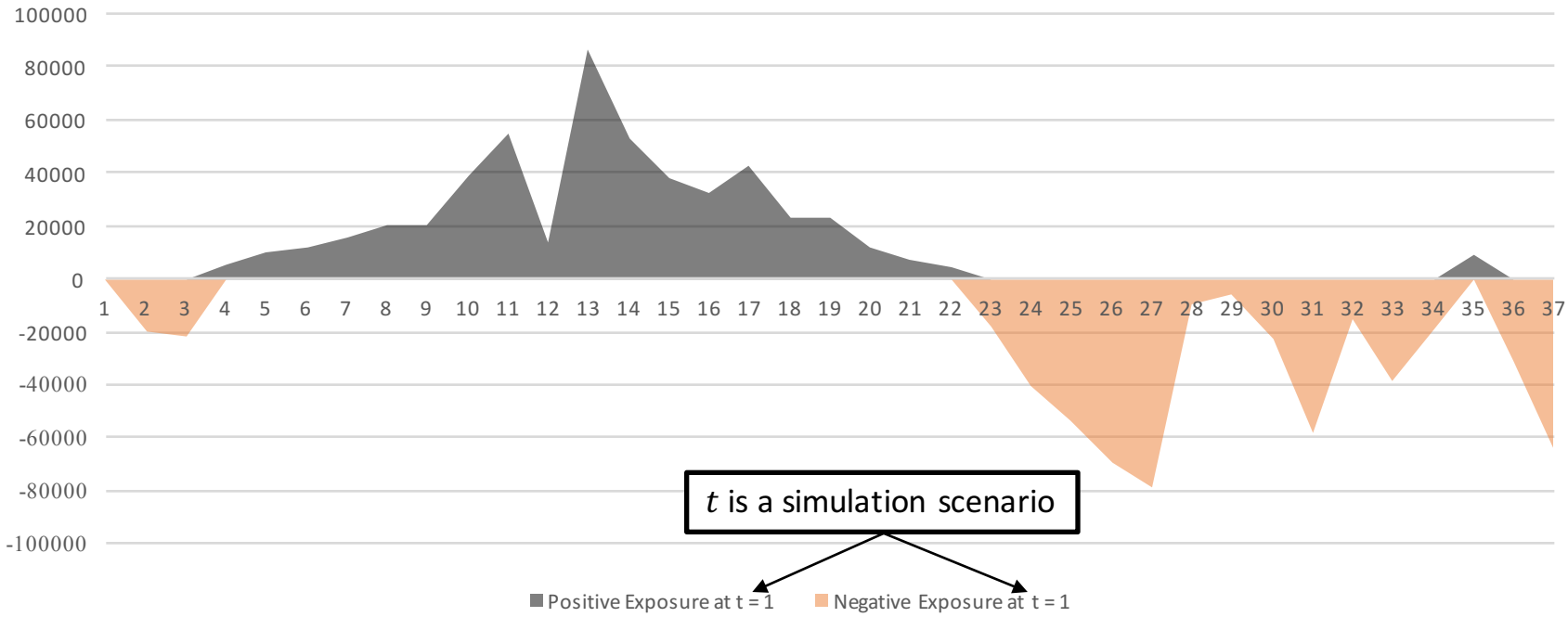
Agenda

- Briefly about Credit Valuation Adjustment
- CVA calculation for the derivatives in question
- Sensitivity analysis – impact of increased volatility on CVA

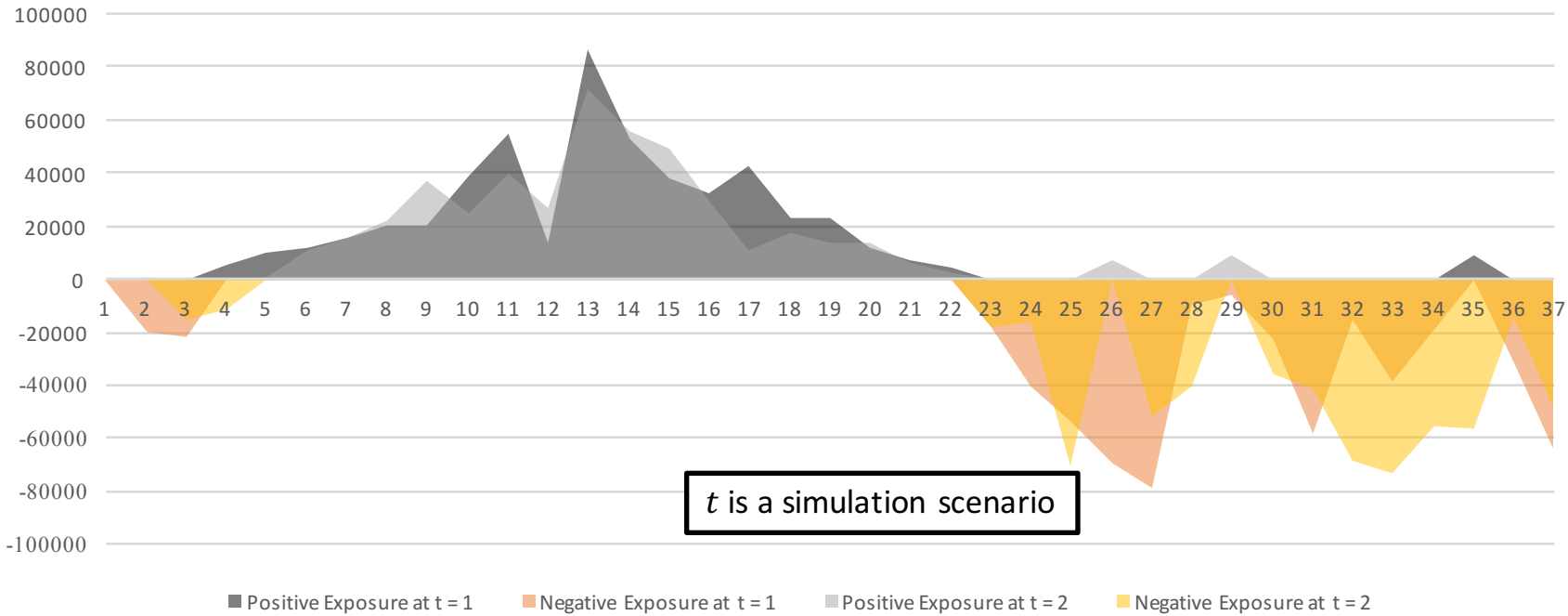
CREDIT VALUATION ADJUSTMENT

The main idea of simulating Exposure



Source: randomly generated data

The main idea of simulating Exposure



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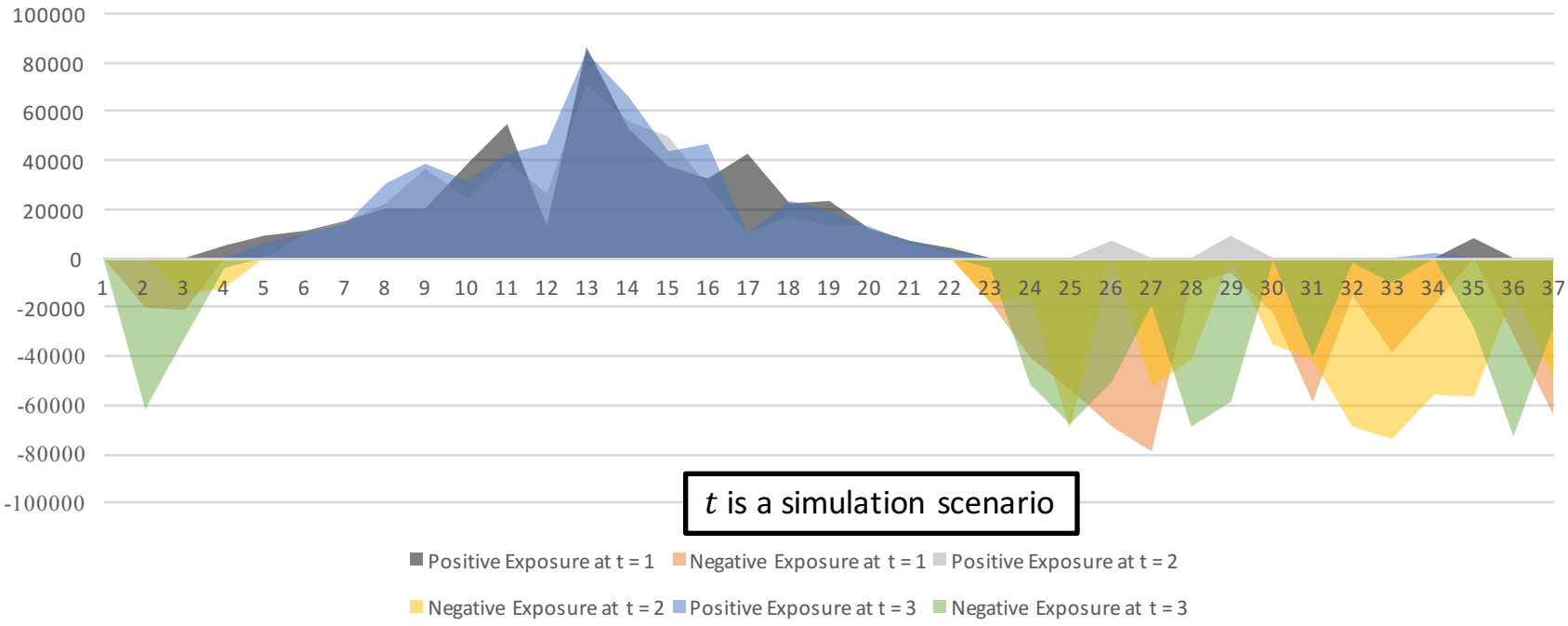

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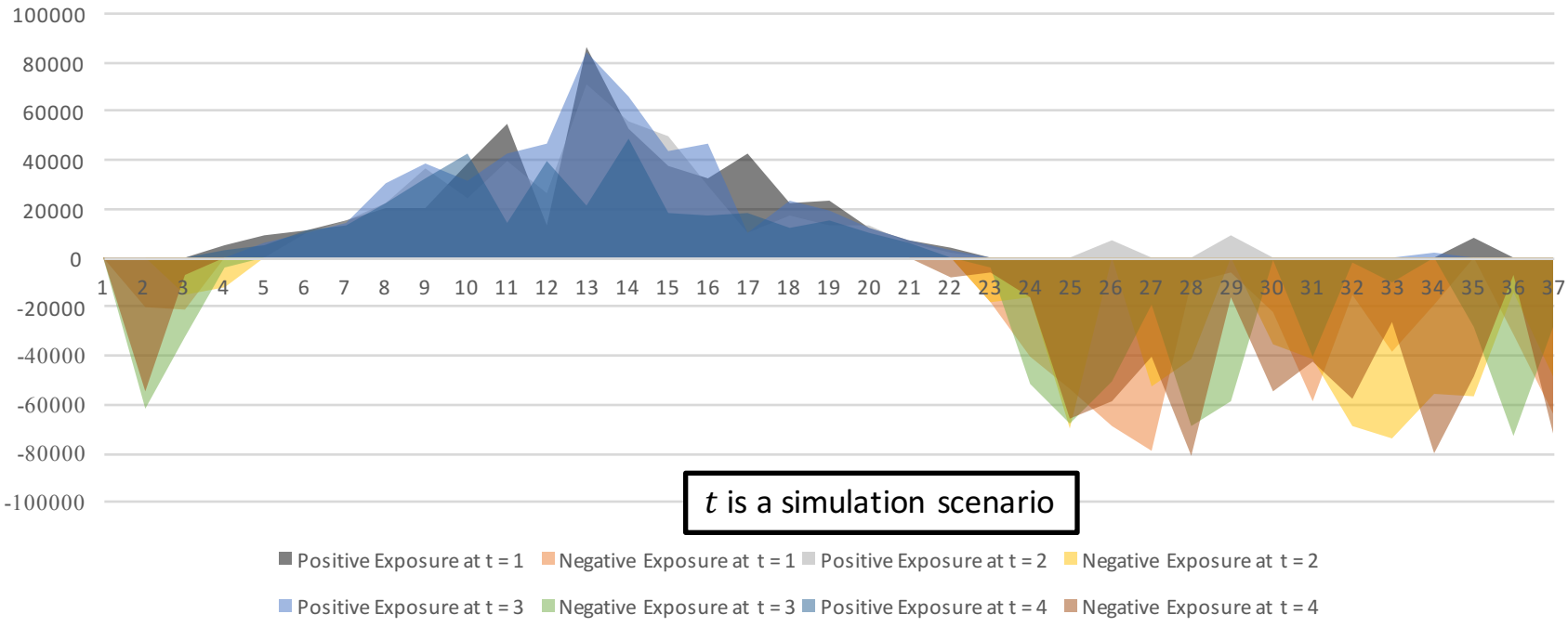
The main idea of simulating Exposure



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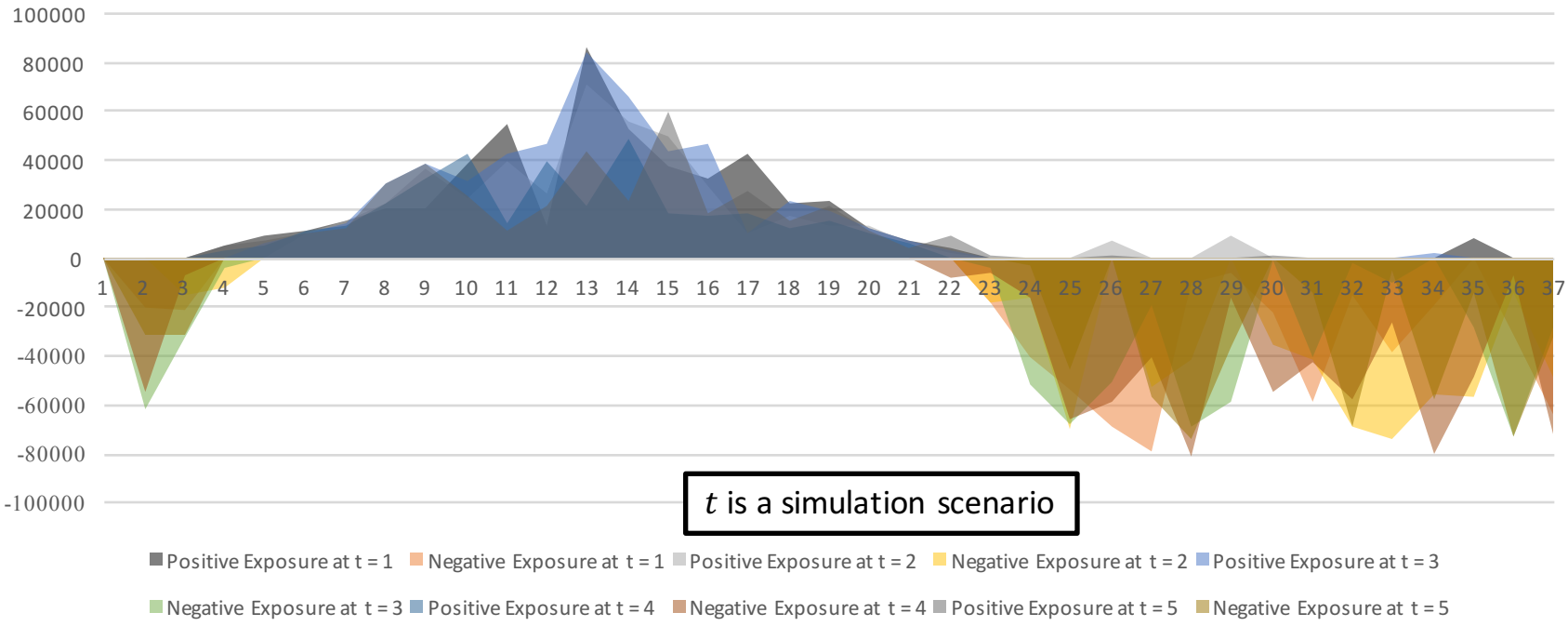
The main idea of simulating Exposure



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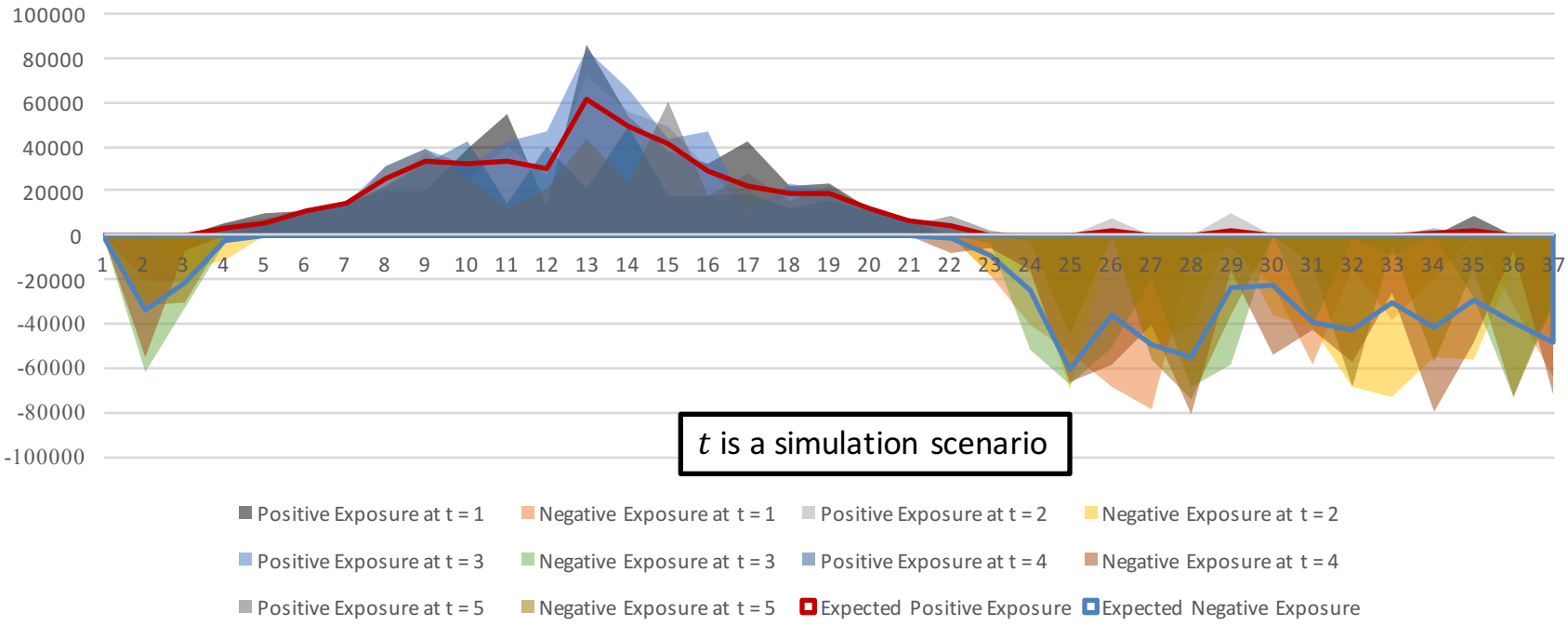
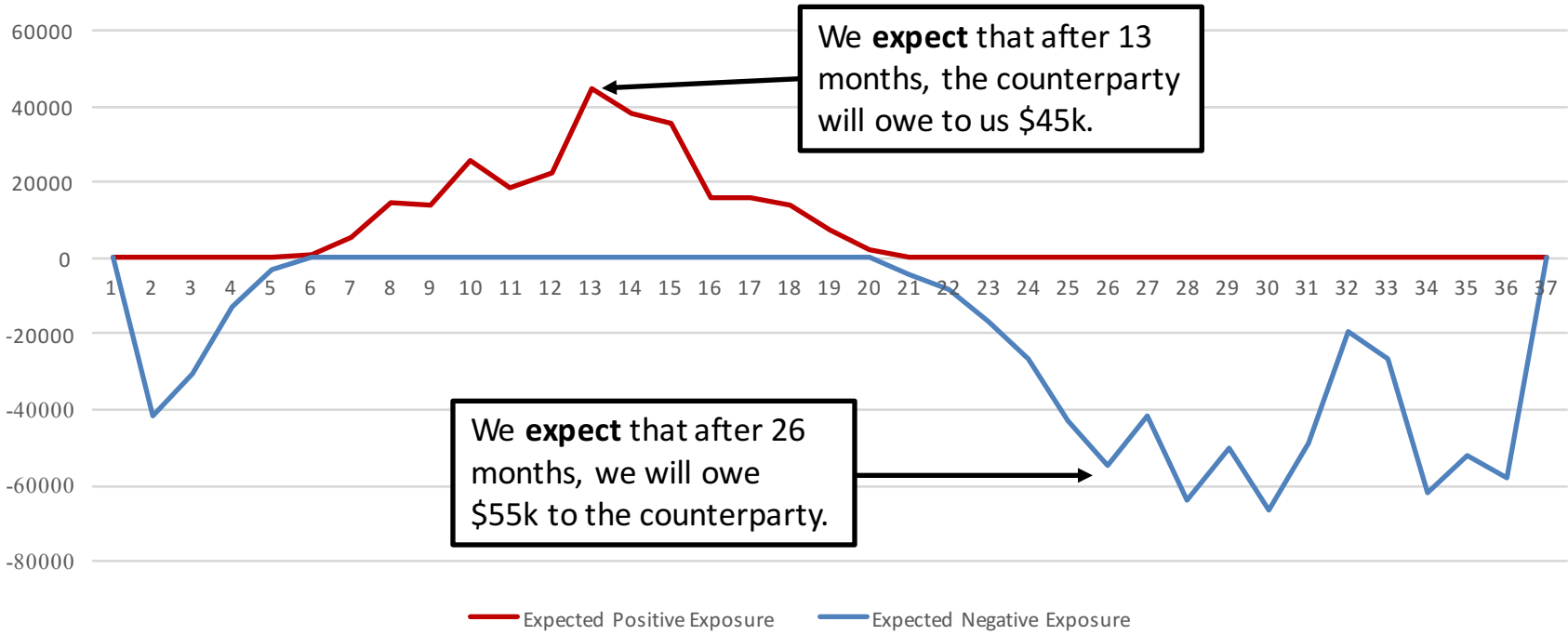
The main idea of simulating Exposure



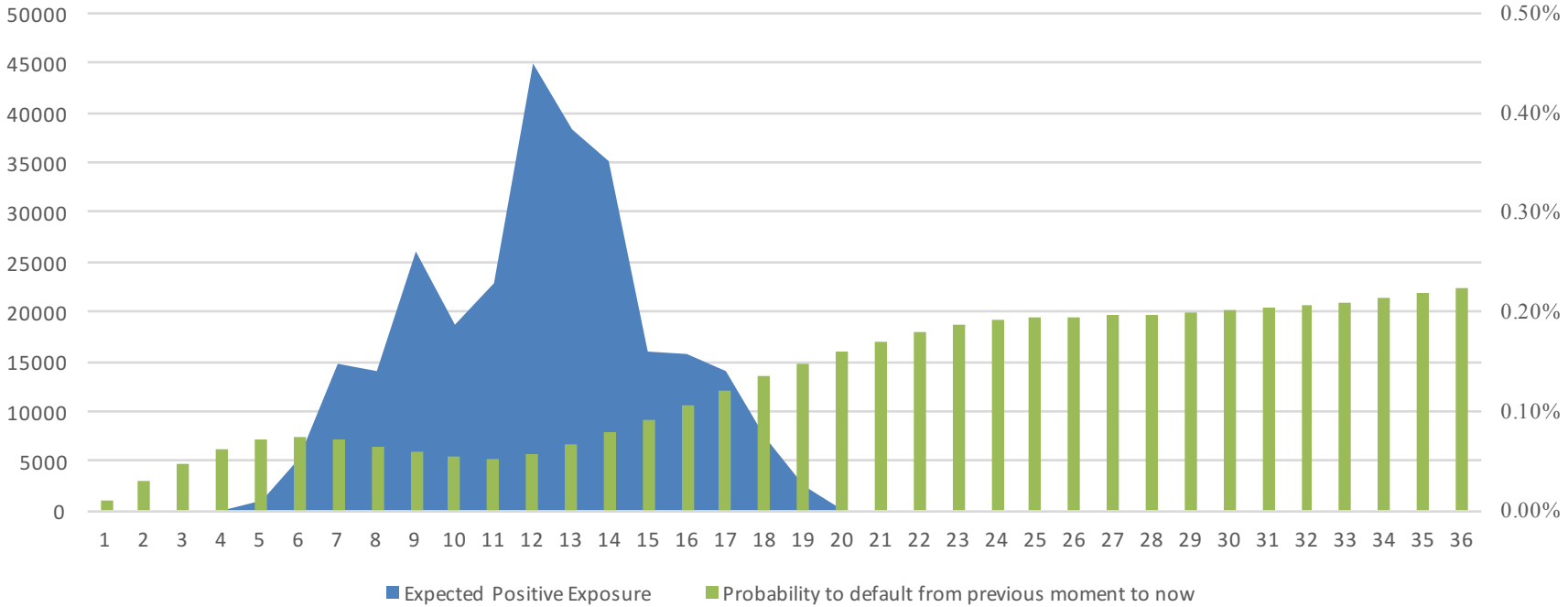
Source: randomly generated data

… is getting Expected Exposure



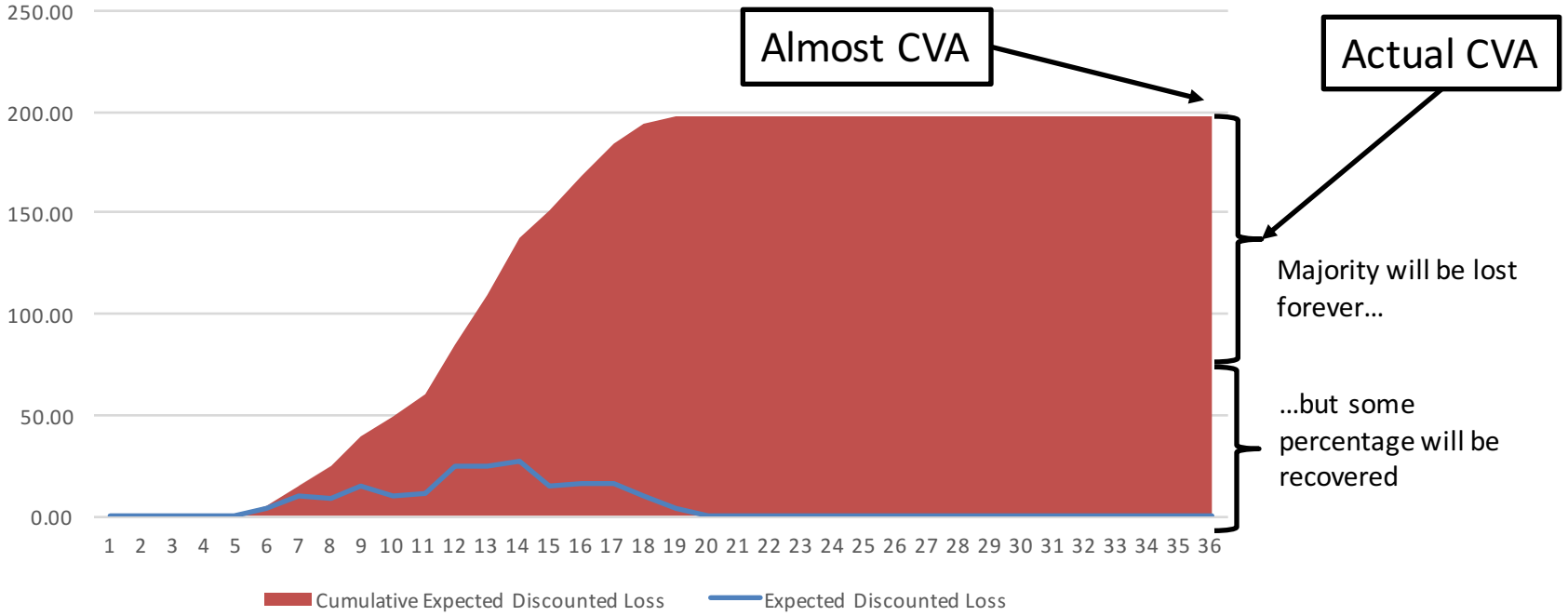
Source: randomly generated data

Combining Expected Exposure and Probability of Default



Source: randomly generated data

Pricing Losses Coming from Default of the Counterparty



Source: randomly generated data

Credit Valuation Adjustment

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's default.

Fair value (CVA included) = Fair value – CVA

Unilateral CVA is given by the risk-neutral expectation of the discounted loss due to counterparty's default can be written as:

$$CVA(T) = E^Q[L^*] = (1-R) \cdot \int_0^T E^Q\left[\frac{B_0}{B_t} \cdot E(t) \middle| t = \tau\right] \cdot dPD(0,t)$$

Source: Wikipedia

Credit Valuation Adjustment

- Assumptions:
  - No Wrong – Way Risk
  - Correlation between defaults of counterparties omitted

$$CVA(t) = LGD \cdot \int_t^T EE(u) \cdot dPD_c(u)$$

Where:
LGD – loss given default,
$EE(u)$ – present value of expected exposure,
$PD_c(u)$ – default probability

Source: Introduction Lecture by dr. Paweł Olsza

Credit Valuation Adjustment

In our case:

$$CVA \approx (1 - R) \cdot \sum_{i=1}^{N} EE(T_i) \cdot DF(0, T_i) \cdot cPD(T_{i-1}, T_i),$$

Where:

$EE(T_i)$ – expected exposure within T_i,

$DF(0, T_i)$ – discount rate for the term T_i,

$cPD(T_{i-1}, T_i) = PS(T_{i-1}) - PS(T_i)$ – marginal probability of counterparty's default for period from T_{i-1} to T_i,

$PS(T_i)$ - survival probability within T_i,

R – recovery rate,

N – number of analyzed points (grid size).

Source: Introduction Lecture by dr. Paweł Olsza; Gregory, 2010

CVA CALCULATION FOR THE DERIVATIVES IN QUESTION

CVA Calculation: completing the puzzle

```
RR <- .4
PD <- -diff(probabilities$PS)/100
DF <- Quotes_data$PLN_DF[-1]

  FWD_EE <- rowMeans(FWD_exposure_sim)[-1]
  IRS_EE <- rowMeans(IRS_exposure_sim)[-1]
  CIRS_EE <- rowMeans(CIRS_exposure_sim)[-1]

    FWD_CVA <-  (1-RR)*sum(FWD_EE* DF[1:12]*PD[1:12])
    IRS_CVA <-  (1-RR)*sum(IRS_EE* DF[1:36]*PD[1:36])
    CIRS_CVA <- (1-RR)*sum(CIRS_EE*DF[1:36]*PD[1:36])
```

$$CVA \approx (1 - R) \cdot \sum_{i=1}^{N} EE(T_i) \cdot DF(0, T_i) \cdot \left(PS(T_{i-1}) - PS(T_i)\right)$$

Source: own research

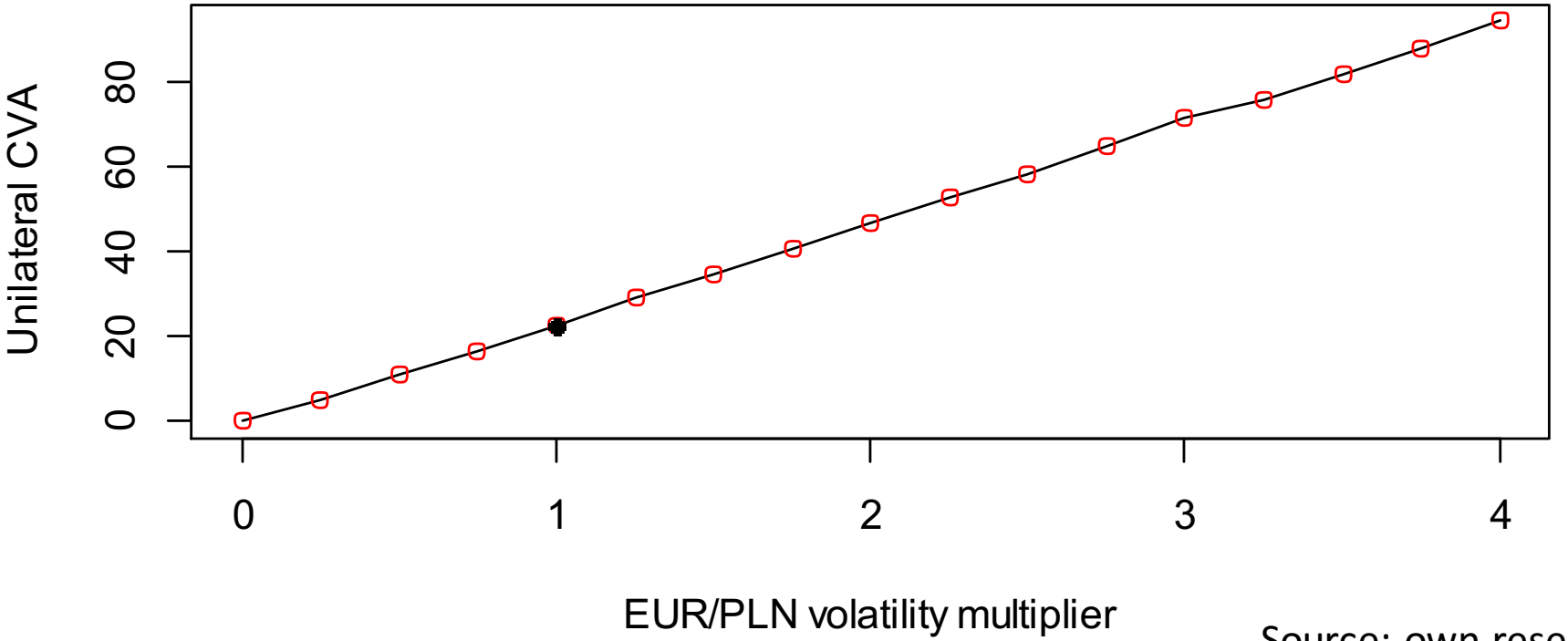
FX Forward CVA Calculation Inputs

```
FX_FWD_CVA(probabilities = implied_probab(CDS_quotes = get_data("CVA_data.xlsx")$CDS_quotes,
                                          Quotes_data = get_data("CVA_data.xlsx")$Quotes_data,
                                          RR = .4, t_s = 1 / 12,
                                          end = 1, spline_method = "natural"),
           Quotes_data =   get_data(file_path = "CVA_data.xlsx")$Quotes_data,
           FX =            stooq(ticker = "EURPLN", from = "20170101",
                                 to = "20181231", interval = "d"),
           EURIBOR_3M =    stooq(ticker = "EUOEUR3M", from = "20170101",
                                 to = "20181231", interval = "d"),
           WIBOR_3M =      stooq(ticker = "PLOPLN3M", from = "20170101",
                                 to = "20181231", interval = "d"),
           FX.vol.sens =   FX_vol.par.mult[i],
           sims =          10000)
```

Source: own research

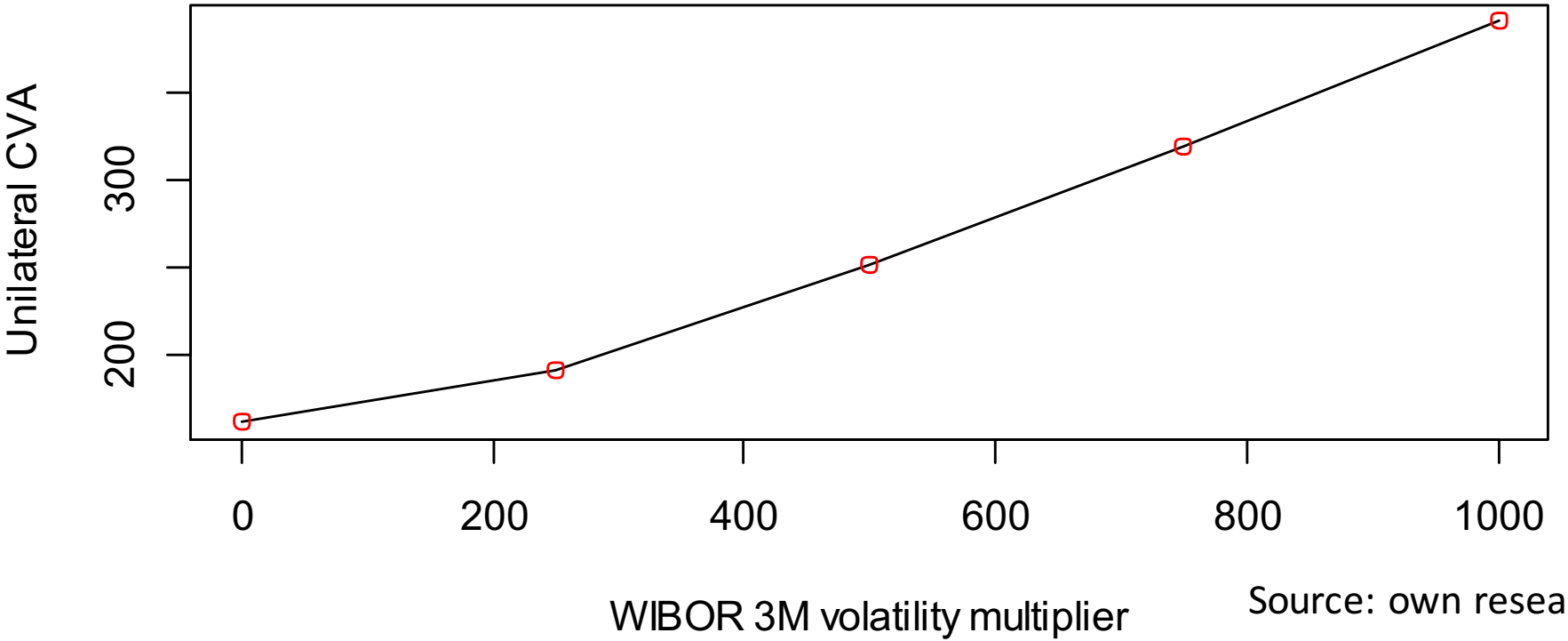
SENSITIVITY ANALYSIS

FX Forward Contract: FX volatility



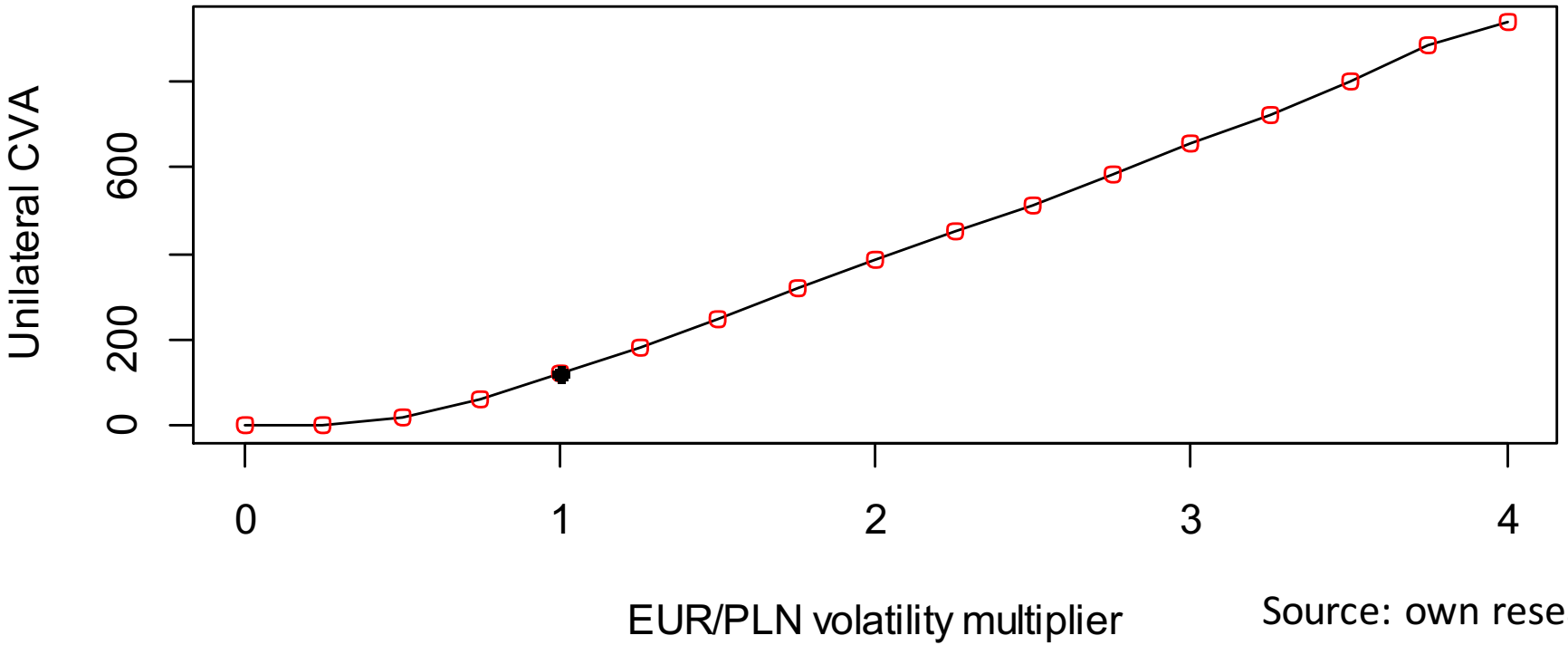
Source: own research

Receiver IRS: WIBOR 3M volatility



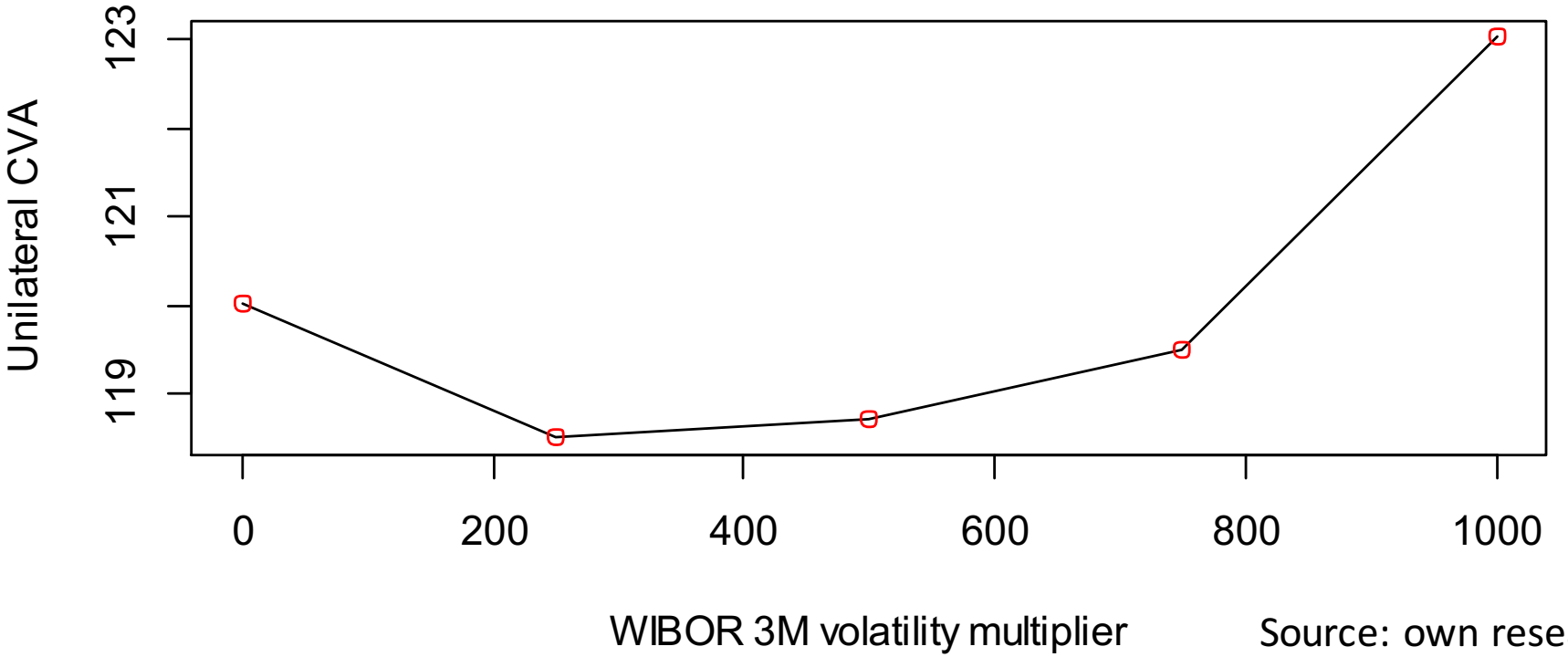
Source: own research

Payer CIRS: FX Volatility



Source: own research

Payer CIRS: WIBOR 3M Volatility



Source: own research

References

- Jon Gregory, *Counterparty Credit Risk: The new challenge for global financial markets*, WileyFinance, 2010
- Financial Engineering Project - Introduction Lecture by dr. Paweł Olsza, 2019