PRACE NAUKOWE
Uniwersytetu Ekonomicznego we Wrocławiu

RESEARCH PAPERS
of Wrocław University of Economics

Nr 381

Financial Investments and Insurance – Global Trends and the Polish Market

edited by

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Publishing House of Wrocław University of Economics

Wrocław 2015

Copy-editing: Agnieszka Flasińska

Layout: Barbara Łopusiewicz

Proof-reading: Barbara Cibis

Typesetting: Małgorzata Czupryńska

Cover design: Beata Dębska

Information on submitting and reviewing papers is available on
the Publishing House's website
www.pracenaukowe.ue.wroc.pl
www.wydawnictwo.ue.wroc.pl

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Wrocław 2015

ISSN 1899-3192
e-ISSN 2392-0041

ISBN 978-83-7695-463-9

The original version: printed

Publication may be ordered in Publishing House
tel./fax 71 36-80-602; e-mail: econbook@ue.wroc.pl
www.ksiegarnia.ue.wroc.pl

Printing: TOTEM

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RESEARCH PAPERS OF WROCŁAW UNIVERSITY OF ECONOMICS nr 381 • 2015

Financial Investment and Insurance – Global Trends and the Polish Market

ISSN 1899-3192
e-ISSN 2392-0041

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COUNTERPARTY CREDIT RISK IN DERIVATIVES

Summary: There is currently a strong market focus on counterparty credit risk. CCR is the risk that a party, usually to an OTC derivative contract, may fail to fulfill its obligations, causing re-placement losses to the other party. This is similar to the standard definition of credit risk in the sense that the economic loss is due to the default of the obligor. However the amount of exposure is uncertain due to the random nature of the contract's pay-offs. The main purpose of this paper is to present the most popular methods for estimating adjustments for credit risk (CVA and DVA) for derivatives.

Keywords: Credit risk, credit exposure, counterparty credit risk, collateral management, credit value adjustment, netting and margin agreement.

DOI: 10.15611/pn.2015.381.20

1. Introduction

Derivative instruments are any type of financial securities that depend on the performance of some type of underlying security in order to have any value. Derivatives can be classified as a unilateral derivative (for example options) or as bilateral derivative (futures, interest rate swap, etc.).[1]

There is currently a strong market focus on counterparty credit risk. CCR is the risk that a party, usually to an OTC derivative contract, may fail to fulfill its obligations, causing losses to the other party. This is similar to the standard definition of credit risk in the sense that the economic loss is due to the default of the obligor. However the amount of exposure is uncertain due to the random nature of the contract's pay-offs. The main purpose of this paper is to present the most popular methods for estimating adjustments for credit risk (CVA and DVA) for derivatives.

[1] Basics of credit value adjustments and implications for the assessment of hedge effectiveness, FINCAD prepared by KPMG 2011.

2. Credit valuation adjustment and debt valuation adjustment

Credit value adjustment is the market value of counterparty credit risk [Zhu, Pykhtin 2007] and can be defined as the difference between the risk-free portfolio value and the true portfolio value that takes into account the possibility of a counterparty's default [Boukhobza, Maetz 2012].

Assuming zero recovery rate, CVA is given by:

$$\mathrm{CVA} := N_0 E_0^{\mathbb{Q}}\left[\frac{V_\tau^+}{N_\tau}\right], \tag{1}$$

where: N – the cash account numeraire; τ – counterparty time.

Alternatively CVA is given by:

$$\mathrm{CVA} = \int_0^T B(0,t)\mathrm{EPE}_t\, dp_t, \tag{2}$$

where: EPE_t – expected positive exposure at time t; p_t – the default probability.

If the exposure at default is a constant K:

$$\mathrm{CVA} = K \times EL_T, \tag{3}$$

where: EL_t – value of the CDS contract of nominal 1 and maturity T:

$$EL_T = \int_0^T B(0,t)\, dp_t, \tag{4}$$

where: p_t – the market implied default probability.

Credit value adjustment is included in calculating the fair value of a derivative by subtracting it from the market valuation [Cesari et al. 2009].

DVA (*debt valuation adjustment*) is CVA from the counterparty's perspective [Morini, Prampolini 2010]. DVA is the amount added back to the MTM value to account for the expected gain from an institution's own default. If one party incurs a CVA loss, the other party records a corresponding DVA gain [Gregor 2010].

Regulation (EU) 575/2013 (Capital Requirements Regulation – CRR) sets out own funds requirements relating to Credit Valuation Adjustment Risk. Institutions should apply the standardised method for the calculation of the CVA charge for exposures to those counterparties which do not produce an appropriate proxy spread with reference to industry, rating and region under the advanced method [Regulation (EU) No 575/2013]. Derivatives traded on exchanges are not subject to counterparty risk, because credit risk is taken by the individual intermediaries, such as stock exchange and brokerage house.

3. Common approaches in credit risk modelling for derivatives

In this section, we present some of the more common approaches in credit risk modelling for derivatives that have been observed in practice. The methods differ in the way they estimate the future exposure profile. Each method has its own advantages and disadvantages and we describe them at the end of each section.

3.1. Expected future exposure approach

This approach is the most theoretically pure approach and takes both current and potential future exposure into account. In expected future exposure approach we simulate market variables that influence the price of a derivative, e.g., stock prices, interest rates, foreign exchange rates, etc. For each scenario, the fair value of the derivative is calculated, which results in an exposure path over the life of the derivative. The scenario can be created based on historical rates of return or generated under the assumption of appropriate distributions. Repeating this procedure, we can create a probability distribution of the valuation of the derivative in different periods of time, averaging the positive exposure and negative exposure results in EPE and ENE, where EPE is the Expected Positive Exposure and ENE the Expected Negative Exposure [Sokol 2012].

$$\mathrm{CVA} = \mathrm{LGD} \sum_{t=1}^{T} d_t \mathrm{EPE}_t {PD_t}^{\mathrm{counterparty}}, \tag{5}$$

$$\mathrm{DVA} = \mathrm{LGD} \sum_{t=1}^{T} d_t \mathrm{ENE}_t {PD_t}^{\mathrm{own}}, \tag{6}$$

where: LGD (loss given default) – the amount of funds that is lost by a bank or other financial institution when a borrower defaults on a loan; d_t – risk-free discount factor; PD_t (probability of default) – estimate of the likelihood that a borrower will be unable to meet its debt obligations.

The CVA calculation uses counterparty PDs, while for DVA, own PDs are used. This method can be applied on transaction level and counterparty level. Nevertheless expected future exposure approach is rather costly to implement, involves complex modelling and requires advanced technical skills.

3.2. Swaption approach

This method is only applicable where the derivative is an interest rate swap (including cross currency IRS). The exposure is modelled as an option on a reversed swap in case the counterparty defaults before the first cash flow date, plus an option on the reversed swap excluding the first cash flow in case the counterparty defaults between the first and second cash flow dates, etc. [Ernst&Young 2014]. As in the previous method the CVA calculation uses counterparty PDs, while for DVA, own PDs are used. CVA is given by:

$$\text{CVA} = \text{LGD}\sum_{t=1}^{T} PD_{\text{counterparty}}(t-1,t)\text{Swaption}_t, \tag{7}$$

where: LGD (loss given default) – the amount of funds that is lost by a bank or other financial institution when a borrower defaults on a loan; $PD(t-1, t)$ (probability of default) – the fair value of an option with expiry t on a swap opposite to the derivative, with maturity $T-t$.

Swaption_t – the probability of default between time $t-1$ and t.

Analogously, DVA is given by:

$$\text{DVA} = \text{LGD}\sum_{t=1}^{T} PD_{\text{own}}(t-1,t)\text{Swaption}_t. \tag{8}$$

Unfortunately it is difficult to apply this method on counterparty level, especially when exposure to a counterparty includes derivatives other than interest rate swaps.

3.3. Constant exposure approach

This approach estimates CVA as the hypothetical cost to purchase credit protection. Notional amount of each CDS is based on the current fair value of the derivative plus the potential future exposure of the derivative.

$$\text{CVA} = \sum_{t=1}^{T} PV_{\text{PREMIUM LEG}}\,(\text{CDS}_t{}^{\text{counterparty}}). \tag{9}$$

CVA is calculated as the present value of the premium legs of this series of CDS. For DVA, own credit spreads are utilised to value the default leg of the CDS:

$$\text{DVA} = \sum_{t=1}^{T} PV_{\text{PREMIUM LEG}}\,(\text{CDS}_t{}^{\text{own}}). \tag{10}$$

Constant exposure approach can be applied at the transaction level and counterparty level. Also method does not requiring assumptions to convert to PD. Nevertheless it does not consider any variability of market variables.

3.4. Variable exposure approach

This approach is an extension of the constant exposure approach. Future exposure of the derivative is forecast under assumption that market evolves according to current forward/futures prices. CVA is calculated as sum of costs of CDS protections for the future exposure between consecutive cash flow data and is given by:

$$\text{CVA} = \sum_{t=1}^{T} PV_{\text{PREMIUM LEG}}\,(\text{CDS}_t). \tag{11}$$

For DVA, own credit spreads are utilised to value the default leg of the CDS:

$$\text{DVA} = \sum_{t=1}^{T} PV_{\text{PREMIUM LEG}}\,(\text{CDS}_t{}^{\text{own}}). \tag{12}$$

As in the previous approach, this method does not require assumptions to convert to PD. Nevertheless it does not consider any variability of interest rates, exchange rates and stock prices that influence derivative fair value.

3.5. Discounted cash flow approach

Discounted cash flow approach can be easily applied to most vanilla derivative valuations. It involves adjusting discount curve by including an additional credit spread to the discounted projected cash flows and use it to calculate $FV_{\text{Credit adjustment}}$ [Ernst&Young 2014].

$$\text{CVA} = FV_{\text{Risk free}} - FV_{\text{Credit adjustment}}. \tag{13}$$

There are four variants of the presented method:

1) own/counterparty spread based on whether current *MtM* position is an asset or liability (does not consider the bilateral nature of derivatives),

2) own/counterparty spread based on whether each individual future cash flow is a net asset or liability,

3) own/counterparty spread based on whether the cumulative net exposure at each cash flow date is a net asset or liability (cash flows in chronological order),

4) own/counterparty spread based on whether the cumulative net exposure at each cash flow date is a net asset or liability (cash flows in receding order with latest cash flows first).

Discounted cash flow approach is not applicable to complex derivatives and it is difficult to apply at counterparty level.

3.6. Duration approach

Duration approach is rather simple and quick. Duration is a measure of the sensitivity of the price (the value of principal) of financial instrument to a change in interest rates [Jajuga (ed.) 2008]. This method uses duration to measure how much the fair value of the derivative changes by applying the credit spread to the risk free valuation.

$$\text{CVA} = MtM \times \text{Credit Spread}_{\text{counterparty}} \times \text{Duration}. \tag{14}$$

The DVA calculation utilises the own credit spread.

$$\text{DVA} = MtM \times \text{Credit Spread}_{\text{own}} \times \text{Duration}. \tag{15}$$

MtM is the current market value of the derivative, assuming neither party is subject to credit risk. This approach can be applied on transaction level and counterparty level. Unfortunately it does not account for potential future exposure.

4. Impact of collateral management on the value of the CVA and DVA

Large impact on the value of the CVA and DVA has collateral management. In a collateralized trade, the party whose contract has a positive present value receives collateral from the counterparty [Piterbarg 2012]. To compensate for this the party has to pay a certain margin called "collateral rate" on the outstanding collateral. In case of cash collateral, the collateral rate is usually the overnight rate for the collateral currency [Burgard 2012].

Collateral management began in the 1980s, with Bankers Trust and Salomon Brothers taking collateral against credit exposure. Collateralisation of derivatives exposures became widespread in the early 1990s. Standardisation began in 1994 via the first ISDA documentation. According to the ISDA Margin Survey [ISDA 2012], close to 80% of all trades with fixed income derivatives during 2012 were collateralized [Hull 2012].

There is a wide range of possible collaterals used to collateralise credit exposure with various degrees of risks. The following types of collaterals are used by parties involved:

1) cash,
2) government securities (often direct obligations of G10 countries: Belgium, Canada, France, Germany, Great Britain, Italy, Japan, Netherlands, Sweden, Switzerland, the US),
3) mortgage-backed securities (MBSs),
4) corporate bonds/commercial papers,
5) letters of credit/guarantees,
6) equities,
7) government agency securities,
8) covered bonds,
9) real estate,
10) metals and commodities.

The most predominant form of collateral is cash and government securities. Collateral management significantly reduces the risk of losses resulting from the bankruptcy of a counterparty. However this does not mean that the risk is not significant.

5. Cross-currency interest rate swap (CCIRS) valuation with the counterparty credit risk

In this section, we present the simplified method for calculating CVA and DVA for collateralized Cross Currency Interest Rate Swap.

In recent years financial institutions have issued debt in foreign markets where they can obtain greater market liquidity and a lower cost of funds. Also many Polish banks hand out mortgage loans in foreign currencies. Such investment strategies pose challenges both from a risk management and an accounting perspective. Volatility in the currency markets can lead to significant translational gains and losses which are then recorded in the P&L Statement.

Cross Currency Interest Rate Swap (an agreement between two parties to exchange interest payments and principals denominated in two different currencies) is commonly applied to hedge foreign currency debt or asset [Jajuga, Jajuga 2004]. There are two main types of cross currency swaps: floating-for-floating and fixed-for-floating. The value of the CCIRS is not only affected by the exchange rate but is also dependent upon the interest rates in the two currencies. From an economic point of view the CCIRS can effectively convert the foreign debt to a synthetic debt in the issuer's functional currency.

The main factor influencing the market value of the CIRS instrument is the level of the exchange rate [Brigo, Mercurio 2006]. The relationship between the exchange rate and the derivative valuation is approximately linear (Figures 1 and 2). R^2 indicates that data fit well a statistical model.

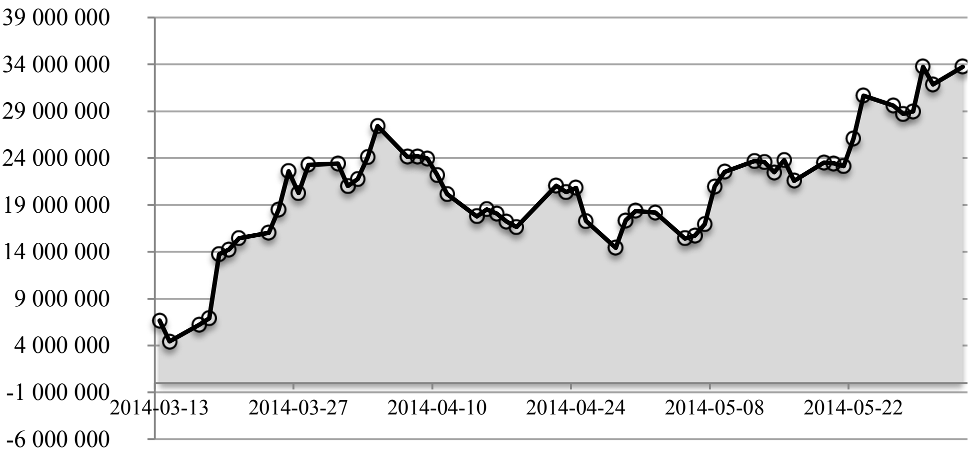

Figure 1. Example of the trajectory of market value of the portfolio of the contract CCIRS

Source: own calculations.

In the proposed method, we simulate market variable that influences the price of a derivative – foreign exchange rates. In this article, we will use the geometric Brownian motion (GBM). This means that the stock price follows a random walk and is consistent with (at the very least) the weak form of the efficient market hypothesis (EMH): past price information is already incorporated and the next price movement is "conditionally independent" of past price movements.

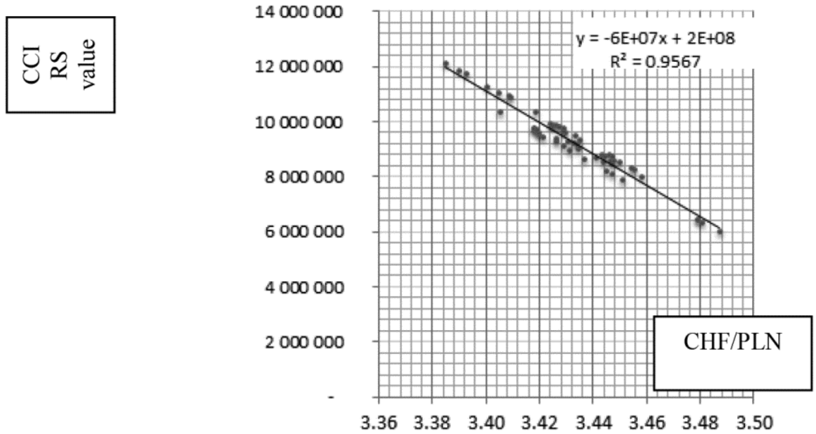

Figure 2. Linear regression approximating the relationship between the exchange rate and the valuation of the sample contract CCIRS

Source: own calculations.

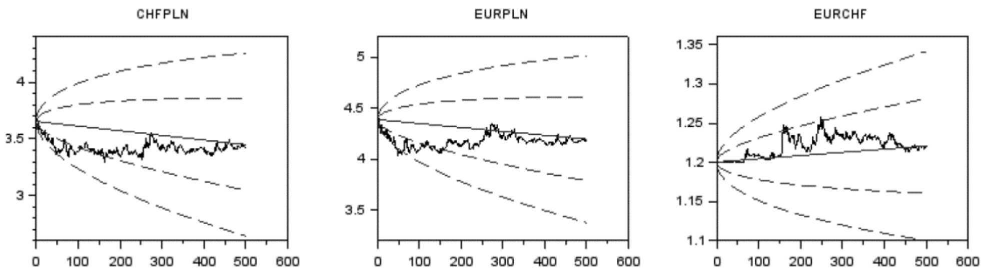

Figure 3. Historical stock quotes (500 days) for currency pairs CHF/PLN, EUR/PLN and EUR/CHF. Blue lines are sigma and 2 × sigma

Source: own calculations.

The formula for GBM stochastic differential equation [Black, Scholes 1973]:

$$\frac{dS_t}{S_t} = \mu dt + \sigma dW_t,$$

where: W_t –Wiener process; μ – the drift; σ – the volatility.

Take the integration of both sides:

$$\int \frac{dS_t}{S_t} = \int (\mu dt + \sigma dW_t) dt.$$

Involving the Ito caluculus:

$$\ln\left(\frac{dS_t}{S_t}\right) = \left(u - \frac{1}{2}\sigma^2\right) t + \sigma W_t.$$

The analytical solution of this geometric Brownian motion is given by:

$$S_t = S_0 \exp\left(\left(u - \frac{1}{2}\sigma^2\right) t + \sigma W_t\right).$$

For each scenario (exchange rate) the fair value of the derivative is calculated, which results in an exposure path over the life of the derivative. Repeating this procedure, we can create a probability distribution of the valuation of the derivative in different periods of time. Averaging the positive exposure and negative exposure results in EPE and ENE, where EPE is the Expected Positive Exposure and ENE the Expected Negative Exposure.

Important factor in calculating EPE and ENE are: Minimum Transfer Amount (MTA) and time after which it is assumed that counterparty went bankrupt and the transaction should be replicated with another counterparty. Minimum Transfer Amount is the smallest amount of currency value that is allowable for transfer as collateral. This is a lower threshold beneath which the transfer is more costly than the benefits provided by collaterization. For large banks, the MTA is usually in the EUR 250,000 range, but can be lower or higher.

CVA and DVA are given by:

$$\mathrm{CVA} = \mathrm{LGD} \sum_{t=1}^{T} d_t \mathrm{EPE}_t {PD_t}^{\mathrm{counterparty}}, \tag{16}$$

$$\mathrm{DVA} = \mathrm{LGD} \sum_{t=1}^{T} d_t \mathrm{ENE}_t {PD_t}^{\mathrm{own}}, \tag{17}$$

where: LGD (loss given default) – the amount of funds that is lost by a bank or other financial institution when a borrower defaults on a loan; d_t – risk-free discount factor; PD_t (probability of default) – estimate of the likelihood that a borrower will be unable to meet its debt obligations.

For the calculation of *PD* were used ratings of counterparties (Table 1).

Table 1. Ratings of counterparties

Rating	Average (1981–2012) One-Year Global Corporate Default Rates
1	2
AAA	0.0000%
AA+	0,0000%
AA	0.0138%
AA–	0.0238%
A+	0.0516%
A	0.0591%
A–	0.0688%
BBB+	0.1497%

1	2
BBB	0.2444%
BBB–	0.2956%
BB+	0.6116%
BB	0.8303%
BB–	1.4016%
B+	2.3563%
B	6.8103%
B–	9.6028%
CCC	23.5272%
CC	23.5272%

Source: own calculations.

5. Conclusions

In this paper we presented the method of calculating Credit Valuation Adjustment and Debt Valuation Adjustment collateral derivative transactions. In the second part of the paper we have considered a simple CVA and DVA model for CCIRS collateralized transaction. Measurement and management of credit risk for derivatives is an important aspect of the risk management in financial institutions. Calculating CVA and DVA for derivatives is not a simple task. Mark-to-market value changes through time depending on the path of the underlying market rates. Since the MTM value can fluctuate in either party's favour, both institutions may be exposed to default risk.

References

Black F., Scholes M., 1973, *The Pricing of Options and Corporate Liabilities*, Journal of Political Economy, vol 81, no. 3, p. 637–654.

Boukhobza A., Maetz J., 2012, *CVA, Wrong Way Risk, Hedging and Bermudan Swaption*, CVA Working Paper, August.

Brigo D., Mercurio F., 2006, *Interest Rate Models. Theory and Practice*, Springer Finance, Springer, Heidelberg.

Burgard C., 2012, *Generalised CVA with Funding and Collateral*, Working Paper.

Cesari G., Aquilina J., Charpillon N., Filipović Z., Lee G., Manda I., 2009, *Modelling, Pricing and Hedging Counterparty Credit Exposure*, Springer Finance.

Ernst&Young, 2014, *Credit Valuation Adjustments for Derivative Contracts*, http://www.ey.com/Publication/vwLUAssets/EY-credit-valuation-adjustments-for-derivative-contracts/$FILE/EY-Applying-FV-April-2014.pdf.

Gregory J., 2010, *Counterparty Credit Risk*, John Wiley & Sons, Chichester.

Hull J., 2012, *Risk Management and Financial Institutions*, John Wiley & Sons, New York.
ISDA, 2012, *ISDA Margin Survey 2012*, International Swaps and Derivatives Association, www2.isda.org/...==/ISDA%20Margin%20Survey%2...
Jajuga K. (ed.), 2008, *Zarządzanie ryzykiem*, Wydawnictwo Naukowe PWN, Warszawa.
Jajuga K., Jajuga T., 2004, *Inwestycje, instrumenty finansowe, aktywa niefinansowe, ryzyko finansowe, inżynieria finansowa*, Wydawnictwo Naukowe PWN, Warszawa.
Morini M., Prampolini A., 2010, *Risky Funding: A Unified Framework for Counterparty and Liquidity Charges*, SSRN Working Paper, http://papers.ssrn.com/sol3/papers.cfm?abstract_ id=1669930.
Piterbarg V., 2012, *Funding beyond Discounting: Collateral Agreements and Derivatives Pricing*, Risk, vol. 24, no. 2, p. 97–102.
Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012 Text with EEA relevance.
Sokol A., 2012, *A Practical Guide to Fair Value and Regulatory CVA*, PRMIA Global Risk Conference, www.prmia.org/sites/default/.../SokolPresentation.pdf.
Zhu S., Pykhtin M., 2007, *A Guide to Modeling Counterparty Risk*, GARP Risk Review, July.

RYZYKO NIEWYPŁACALNOŚCI KONTRAHENTA NA RYNKU INSTRUMENTÓW POCHODNYCH

Streszczenie: Każda instytucja finansowa zawierająca kontrakty na rynku nieregulowanym bez usług pośrednika narażona jest na ryzyko kredytowe związane z prawdopodobieństwem bankructwa kontrahenta. Istotność pomiaru ryzyka kredytowego wynikającego z transakcji na rynku instrumentów pochodnych została unaoczniona w latach 2007–2009, kiedy doszło do bankructwa banku inwestycyjnego Lehman Brothers, a wiele innych instytucji finansowych poniosło straty z tytułu transakcji zawartych z bankrutującym bankiem. Zarządzanie ryzykiem niewypłacalności kontrahenta na rynku instrumentów pochodnych jest zagadnieniem niezwykle istotnym, ze względu na wpływ na aktualny pozom wartości godziwej instrumentu pochodnego oraz na poziom wymogu kapitałowego. Bardzo często prawdopodobieństwo niewykonania zobowiązania przez kontrahentów pozostaje w korelacji dodatniej z ogólnymi czynnikami ryzyka rynkowego. Celem artykułu jest przedstawienie metod modelowania ryzyka kredytowego na rynku instrumentów pochodnych.

Słowa kluczowe: ryzyko kredytowe, ryzyko kontrahenta, depozyt zabezpieczający.