Pre-Settlement Risk

Chelsea Anne Go, Brian Godwin Lim

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1 Introduction

Counterparty credit risk refers to the risk that arises when an entity with whom one has entered into a financial contract (the counterparty) fails to fulfill its side of the contractual agreement. Counterparty credit risk is different from lending risk. On the one hand, lending risk typically applies to loans, bonds, and mortgages. Exposure to lending risk is certain since the notional amount at risk at any time during the lending period is usually known with a degree of certainty. Moreover, only one party is exposed to lending risk. On the other hand, counterparty credit risk typically applies to over-the-counter (OTC) derivatives and securities financing transactions. Exposure to counterparty credit risk is uncertain since the value of the contract in the future is uncertain (as seen today). Hence, the notional amount at risk at a potential default date is also uncertain. Furthermore, the exposure is bilateral since the value of the contract can be positive or negative. This means that both parties in the transaction are exposed to counterparty credit risk.

Moreover, there are also two types of counterparty credit risk: pre-settlement risk and settlement risk. However, counterparty credit risk usually refers to the former. Pre-settlement risk (PSR) refers to the risk that the counterparty defaults before the final settlement of the transaction. The loss from pre-settlement risk depends on the replacement value of the contract at the time of default. In contrast, settlement risk refers to the risk when contractual payments are not received on the settlement date due to default. This arises at final settlement when there are timing differences between when each party performs on its obligations under the contract.

Likewise, there are several methods in calculating counterparty credit exposure. These include simple add-on methods based on a fixed percentage of the notional amount to Monte Carlo simulation. Most local banks use a method analogous to but more model-based than the add-on method.

The calculation of counterparty credit exposure is as follows. Suppose at any time t during the life of a contract, the mark-to-market (MtM) value is V_t. Then, the credit exposure is given as

$$\begin{aligned}\text{PSR Exposure}(t) &= \text{Current Exposure} + \text{Add-on}\\ &= \max\left(0, V_t\right) + \text{Potential Future Exposure}.\end{aligned}$$

The Potential Future Exposure at time t, denoted by PFE_t, is the maximum additional amount over the Current Exposure that will be lost at some time τ between time t and the maturity T of the contract. This can be expressed as

$$\text{PFE}_t = \max\left(0, \max_{\tau\in(t,T)}\left\{\text{PV}_t\left(V_\tau\right) - V_t\right\}\right),$$

where $\text{PV}_t(\cdot)$ is the present value function that discounts the values to time t. Thus, the above equation can be rewritten as

$$\text{PSR Exposure}(t) = \max\left(0, V_t\right) + \max\left(0, \max_{\tau\in(t,T)}\left\{\text{PV}_t\left(V_\tau\right) - V_t\right\}\right).$$

Pre-settlement risk (PSR) exposure is typically calculated to charge against appropriate credit lines assigned to a counterparty at inception date $t = 0$. Moreover, at inception, the mark-to-market (MtM) value of the contract is near zero. Hence, it suffices to focus on the Potential Future Exposure (PFE) when calculating the PSR exposure. Additionally, the goal is to obtain a constant, called the PFE factor, which, when multiplied to the notional amount of the contract, gives an estimate of the PFE at a given confidence level, *i.e*,

$$\text{maximum PFE} = (\text{PFE factor}) \times (\text{Notional of the contract}).$$

Thus, it suffices to have a model for calculating the PFE factor.

There are several methods of calculating the PFE factor. However, the parametric (delta-normal) approach and the historical simulation approach are the most commonly used methods by local banks. On the one hand, in the delta-normal approach, the returns are assumed to follow a normal distribution with mean 0 and standard deviation estimated from historical data. However, a closed form is not always easily obtained especially when the transactions involve derivatives. On the other hand, in the historical simulation approach, historical market rates are used to estimate the credit exposure on hypothetical contracts at discrete points in time from inception until its maturity. The 1st and 99th percentiles of all values are then obtained to account for credit exposure for both long and short positions in the contracts. The maximum value between the absolute value of the 1st and 99th percentile is then the PFE factor under this method.

2 Pre-Settlement Risk for FX Spot Transactions

An FX spot transaction typically takes 3 days after the deal date to settle. Hence, both parties in the transaction are exposed to counterparty credit risk each day before the actual settlement. Thus, in calculating the PFE factor for a given a currency pair, the credit exposure is calculated for day 1, day 2, and day 3.

Consider the base currency C_b and the quote currency C_q. The exchange rate is expressed as units of the quote currency per unit of the base currency. Suppose an FX spot transaction is initiated today where a notional amount L_b units of base currency is exchanged for L_c units of quote currency. Let y_0 be the exchange rate today from the base currency to the quote currency. At any time on or before the settlement, the mark-to-market (MtM) value of the transaction to either party is the net cash flow at that particular time, *i.e.*, the amount received minus the amount paid, both expressed in the same currency. Since the mark-to-market (MtM) ratio today of the transaction must be 0, then

$$L_c = L_b \cdot y_0.$$

Let y_n be the exchange rate from the base currency to the quote currency n days from today, where $n = 1, 2, 3$. Then, the mark-to-market (MtM) of the transaction on day n to the party with long position in the base currency is given by

$$V_n = L_b \cdot y_n - L_c.$$

It is important to note that when $n = 0$,

$$V_0 = L_b \cdot y_0 - L_c = 0.$$

Moreover, since $L_b = \dfrac{L_c}{y_0}$, then

$$\begin{aligned} V_n &= \frac{L_c}{y_0} \cdot y_n - L_c \\ &= L_c \cdot \left(\frac{y_n}{y_0} - 1 \right) \\ &= L_c \cdot \underbrace{\left(\frac{y_n - y_0}{y_0} \right)}_{R_n}. \end{aligned}$$

Let $R_n = \dfrac{y_n - y_0}{y_0}$ be the (unknown) n-day arithmetic return. The pre-settlement risk exposure at inception date is the potential future exposure at a specified confidence level. Moreover, in practice, for spot transactions, the mark-to-market (MtM) value on day n is no longer discounted to time $t = 0$ since the time interval is short. Hence, the PFE factor for an FX spot transaction is the maximum value of R_n for all n.

Using the historical simulation approach, the PFE factor is calculated as follows. Suppose x_j is the exchange rate from the base currency to the quote currency j days ago, where $j = 0, 1, \ldots, N$. Moreover, for $n = 1, 2, 3$, let

$$R'_{j,n} = \frac{x_j - x_{j+n}}{x_{j+n}}$$

be the n-day arithmetic return j days ago. Then, the absolute value of the 1st percentile of the set $\left\{R'_{j,n} : j = 0, 1, \ldots, N, n = 1, 2, 3\right\}$, denoted by $\text{PFE}_{1\%}$, is the PFE factor for the FX spot transaction involving a short position in the base currency (long position in the quote currency). The absolute value of the 99th percentile of the same set, denoted by $\text{PFE}_{99\%}$, is the PFE factor for the FX spot transaction involving a long position in the base currency (short position in the quote currency). Finally, the PFE factor for the FX spot transaction is given by

$$\max\left(\text{PFE}_{1\%}, \text{PFE}_{99\%}\right),$$

which covers both long and short position in the transaction.

2.1 Assumptions

The following assumptions are made in calculating the PFE factor.

1. The PFE factor is calculated for three currency pairs: USD/PHP, USD/JPY, and EUR/USD.

2. The date today is March 27, 2013.

3. The PFE factors are obtained using the historical simulation approach and using 260 scenarios.

4. An FX spot transaction is assumed to take 3 days after the deal date to settle.

5. The 1st and 99th percentiles of the arithmetic returns are obtained using the `PERCENTILE()` function in Excel.

2.2 Excel Implementation

The calculation of the PFE factors using Excel is shown below.

1. First, the historical exchange rates from March 22, 2012 to March 27, 2013 (263 trading days) for the three currency pairs are considered. Using these, the 1-day, 2-day, and 3-day arithmetic returns are calculated for 260 scenarios.

Scenario	Date	USD/PHP			
		FX Rate	1-day Return	2-day Return	3-day Return
1	3/27/2013	40.80	-0.0032	-0.0005	-0.0017
2	3/26/2013	40.93	0.0027	0.0015	0.0050
3	3/25/2013	40.82	-0.0012	0.0022	0.0020
4	3/22/2013	40.87	0.0034	0.0032	0.0038
5	3/21/2013	40.73	-0.0002	0.0004	0.0015
6	3/20/2013	40.74	0.0006	0.0017	0.0028
7	3/19/2013	40.71	0.0011	0.0022	0.0026
8	3/18/2013	40.67	0.0011	0.0015	0.0027
Scenario	Date	USD/JPY			
		FX Rate	1-day Return	2-day Return	3-day Return
1	3/27/2013	94.46	0.0002	0.0031	0.0000
2	3/26/2013	94.44	0.0029	-0.0002	-0.0048
3	3/25/2013	94.17	-0.0031	-0.0077	-0.0192
4	3/22/2013	94.46	-0.0046	-0.0161	-0.0074
5	3/21/2013	94.90	-0.0116	-0.0027	-0.0033
6	3/20/2013	96.01	0.0089	0.0084	0.0077
7	3/19/2013	95.16	-0.0005	-0.0013	-0.0099
8	3/18/2013	95.21	-0.0007	-0.0094	-0.0096
Scenario	Date	EUR/USD			
		FX Rate	1-day Return	2-day Return	3-day Return
1	3/27/2013	1.28	-0.0063	-0.0057	-0.0161
2	3/26/2013	1.29	0.0006	-0.0099	-0.0029
3	3/25/2013	1.29	-0.0105	-0.0036	-0.0062
4	3/22/2013	1.30	0.0070	0.0043	0.0083
5	3/21/2013	1.29	-0.0026	0.0013	-0.0045
6	3/20/2013	1.29	0.0040	-0.0019	-0.0109
7	3/19/2013	1.29	-0.0058	-0.0148	-0.0095
8	3/18/2013	1.30	-0.0091	-0.0037	-0.0003

Figure 1: FX Spot: n-day Arithmetic Return

2. For each currency pair, the maximum of the absolute values of the 1st percentile and 99th percentile for the 1-day, 2-day, and 3-day returns are obtained using the `MAX(ABS(PERCENTILE()))` functions of Excel. Since most banks use an estimation method for the PFE factor, the suggested PFE factors can be obtained by rounding up the actual PFE factors to the nearest 0.25%. This is calculated in Excel using the `CEILING()` function. The maximum value across the 1-day, 2-day, and 3-day is then the final suggested PFE factor.

PFE Factor			
	1-day	2-day	3-day
USD/PHP			
max(abs(1%),abs(99%))	0.7888%	0.9343%	1.3179%
suggested PFE Factor	1.0000%	1.0000%	1.5000%
PFE Factor		**1.5000%**	

PFE Factor			
	1-day	2-day	3-day
USD/JPY			
max(abs(1%),abs(99%))	1.4942%	2.0137%	2.4604%
suggested PFE Factor	1.5000%	2.2500%	2.5000%
PFE Factor		**2.5000%**	

PFE Factor			
	1-day	2-day	3-day
EUR/USD			
max(abs(1%),abs(99%))	1.5169%	1.7959%	2.0588%
suggested PFE Factor	1.7500%	2.0000%	2.2500%
PFE Factor		**2.2500%**	

Figure 2: FX Spot: PFE Factors

2.3 Results and Discussion

The PFE factors obtained for the currency pairs USD/PHP, USD/JPY, and EUR/USD are 1.50%, 2.50%, and 2.25%, respectively. It is worth noting that the PFE factors are obtained from the 3-day arithmetic returns for all currency pairs. Moreover, the currency pair USD/JPY has the highest level of risk exposure since it has the highest PFE factor. This indicates that in the span of 3 days, the value of the spot transaction can increase or decrease by 2.50% with 99% confidence level. Meanwhile, the currency pair USD/PHP has the least level of risk exposure. Overall, the results indicate that delays in the settlement of spot transactions exposes both parties to some degree of risk.

3 Pre-Settlement Risk for FX Forward Transactions

An FX forward contract is a binding agreement to buy or sell a specified amount of base currency for an equivalent amount of quote currency at a future date. The agreement locks in a future exchange rate between the two currencies at deal date. In calculating the PFE factor of the transaction, the forward contract is valued at discrete points during the life of the contract, *i.e.*, valuation is done monthly, weekly, or daily, until settlement date.

Consider the base currency C_b, the quote currency C_q, and S_t the exchange rate at time t from C_b to C_q. Additionally, let $r_{b,t,T}$ and $r_{q,t,T}$ be the continuously compounded zero rate with tenor $T-t$ at time t in currency C_b and C_q, respectively. In a foreign exchange forward, the long position party agrees to buy the base currency, in terms of the quote currency, for the forward exchange rate F_0 at the delivery date $t = T$. Suppose at deal date $t = 0$, the forward contract initiated is to exchange L_b units of base currency for L_q units of quote currency. Thus, the forward exchange rate locked is effectively

$$F_0 = \frac{L_q}{L_b}.$$

Furthermore, the mark-to-market (MtM) value of the contract at $t = 0$ is usually zero. Meanwhile, the forward exchange rate F_t at time t from the base currency C_b to the quote currency C_q is given by

$$F_t = S_t e^{\left(r_{q,t,T} - r_{b,t,T}\right)(T-t)}.$$

Hence, the mark-to-market (MtM) value of the FX forward contract at time t to the party with long position is

$$\begin{aligned} V_t &= L_b \left(F_t - F_0\right) e^{-r_{q,t,T}(T-t)} \\ &= \frac{L_q}{F_0} \left(F_t - F_0\right) e^{-r_{q,t,T}(T-t)} \\ &= L_q \left(\frac{F_t}{F_0} - 1\right) e^{-r_{q,t,T}(T-t)}. \end{aligned}$$

From the equation above, the credit exposure $\left(\frac{F_t}{F_0} - 1\right) e^{r_{q,t,T}(T-t)}$ can be used to derive the PFE factor at a given confidence level for discrete points of t.

Using the historical simulation approach, the PFE factor is calculated as follows. Suppose

$$R_{j,t} = \left(\frac{F_{j,t}}{F_{j,0}} - 1\right) e^{r_{j,q,t,T}(T-t)},$$

where $F_{j,t}$ is the forward rate at time t with tenor $T - t$ for the jth scenario, $F_{j,0}$ is the forward rate locked with tenor T for the jth scenario, and $r_{j,q,t,T}$ is the continuously compounded zero rate in currency C_q at time t with tenor $T - t$ for the jth scenario. Suppose further that the valuation is done discretely over the set τ, *i.e.*, $\tau = \left\{\frac{1}{12}, \frac{2}{12}, \frac{3}{12}\right\}$ if a 3-month FX forward contract is valued monthly. Denote $\text{PFE}_{1\%}$ as the absolute value of the 1st percentile of the set $\{R_{j,t} : j = 0, 1, \ldots, N, t \in \tau\}$ and $\text{PFE}_{99\%}$ as the absolute value of the 99th percentile of the same set. Then, the PFE factor for the FX forward transaction is given by

$$\max\left(\mathrm{PFE}_{1\%}, \mathrm{PFE}_{99\%}\right),$$

which covers both long and short position in the transaction.

3.1 Assumptions

The following assumptions are made in calculating the PFE factor.

1. The FX forward considered is assumed to have USD as the base currency and PHP as the quote currency.
2. The date today is March 27, 2013.
3. The PDST-R2 and LIBOR rates given are assumed to be simple rates.
4. One month is assumed to have 21 trading days.
5. The historical market data for the past 260+ trading days are considered to generate 260 scenarios. For the 3-month FX forward, the historical market data from December 29, 2011 to March 27, 2013 (323 trading days) are considered. For the 6-month FX forward, the historical market data from October 3, 2011 to March 27, 2013 (386 trading days) are considered.
6. The credit exposure is computed every month until the maturity of the forward transaction.
7. The 1st and 99th percentiles of the credit exposure each month are obtained using the `PERCENTILE()` function in Excel.

3.2 Excel Implementation

The calculation of the PFE factors using Excel is shown below. For brevity, only the 3M FX forward contract is shown.

1. First, the monthly PDST-R2 and LIBOR rates are obtained. Missing tenors are interpolated using the `FORECAST()` function.

Scenario	Trade Date	USD/PHP	PDST-R2			LIBOR		
			1M	3M	2M	1M	2M	3M
1	3/27/2013	40.80	0.3000%	0.2500%	0.2750%	0.2037%	0.2430%	0.2836%
2	3/26/2013	40.93	0.3000%	0.2500%	0.2750%	0.2037%	0.2430%	0.2836%
3	3/25/2013	40.82	0.3000%	0.2500%	0.2750%	0.2042%	0.2425%	0.2831%
4	3/22/2013	40.87	0.2400%	0.1900%	0.2150%	0.2042%	0.2435%	0.2846%
5	3/21/2013	40.73	0.2400%	0.1900%	0.2150%	0.2042%	0.2430%	0.2841%
6	3/20/2013	40.74	0.2400%	0.1900%	0.2150%	0.2047%	0.2430%	0.2841%
7	3/19/2013	40.71	0.2400%	0.1900%	0.2150%	0.2037%	0.2420%	0.2821%
8	3/18/2013	40.67	0.2400%	0.1900%	0.2150%	0.2032%	0.2415%	0.2801%

Figure 3: FX Forward: Simple PDST-R2 and LIBOR Rates

2. Afterwards, the monthly PDST-R2 and LIBOR rates are converted into continuously compounded rates by
$$\frac{\ln\left(1+r_t\left(T-t\right)\right)}{T-t}.$$

Scenario	Trade Date	USD/PHP	PDST-R2 1M	PDST-R2 2M	PDST-R2 3M	LIBOR 1M	LIBOR 2M	LIBOR 3M
1	3/27/2013	40.80	0.3000%	0.2749%	0.2499%	0.2037%	0.2430%	0.2835%
2	3/26/2013	40.93	0.3000%	0.2749%	0.2499%	0.2037%	0.2430%	0.2835%
3	3/25/2013	40.82	0.3000%	0.2749%	0.2499%	0.2042%	0.2425%	0.2830%
4	3/22/2013	40.87	0.2400%	0.2150%	0.1900%	0.2042%	0.2435%	0.2845%
5	3/21/2013	40.73	0.2400%	0.2150%	0.1900%	0.2042%	0.2430%	0.2840%
6	3/20/2013	40.74	0.2400%	0.2150%	0.1900%	0.2047%	0.2430%	0.2840%
7	3/19/2013	40.71	0.2400%	0.2150%	0.1900%	0.2037%	0.2420%	0.2820%
8	3/18/2013	40.67	0.2400%	0.2150%	0.1900%	0.2032%	0.2415%	0.2800%

Figure 4: FX Forward: Continuous PDST-R2 and LIBOR Rates

3. Next, the forward rates for each scenario are obtained using the formula presented earlier.

Scenario	Deal Date	Reference Date	USD/PHP	PDST-R2 3M	LIBOR 3M	$F_{0,3}$
1	12/27/2012	12/27/2012	41.13	0.2999%	0.3109%	41.12387
2	12/26/2012	12/26/2012	41.15	0.3249%	0.3099%	41.15154
3	12/24/2012	12/24/2012	41.13	0.2999%	0.3099%	41.12797
4	12/21/2012	12/21/2012	41.14	0.2999%	0.3099%	41.13397
5	12/20/2012	12/20/2012	41.10	0.2999%	0.3099%	41.09397
6	12/19/2012	12/19/2012	41.04	0.3149%	0.3099%	41.04051
7	12/18/2012	12/18/2012	41.08	0.3149%	0.3089%	41.08062
8	12/17/2012	12/17/2012	41.06	0.3498%	0.3089%	41.06421

Scenario	Deal Date	Reference Date	USD/PHP	PDST-R2 2M	LIBOR 2M	$F_{1,3}$
1	12/27/2012	1/28/2013	40.97	0.1525%	0.2474%	40.95852
2	12/26/2012	1/25/2013	40.66	0.1250%	0.2484%	40.64664
3	12/24/2012	1/24/2013	40.64	0.1250%	0.2484%	40.62964
4	12/21/2012	1/23/2013	40.63	0.1250%	0.2494%	40.62157
5	12/20/2012	1/22/2013	40.61	0.1250%	0.2494%	40.59658
6	12/19/2012	1/21/2013	40.75	0.1250%	0.2494%	40.74155
7	12/18/2012	1/18/2013	40.58	0.1250%	0.2494%	40.57258
8	12/17/2012	1/17/2013	40.62	0.1250%	0.2499%	40.61454

Scenario	Deal Date	Reference Date	USD/PHP	PDST-R2 1M	LIBOR 1M	$F_{2,3}$
1	12/27/2012	2/26/2013	40.76	0.2500%	0.2037%	40.75657
2	12/26/2012	2/25/2013	40.68	0.2500%	0.2027%	40.6816
3	12/24/2012	2/22/2013	40.72	0.2500%	0.2027%	40.7216
4	12/21/2012	2/21/2013	40.77	0.2500%	0.2017%	40.76864
5	12/20/2012	2/20/2013	40.62	0.2500%	0.2017%	40.62163
6	12/19/2012	2/19/2013	40.63	0.2500%	0.2017%	40.63164
7	12/18/2012	2/18/2013	40.64	0.2500%	0.2007%	40.64167
8	12/17/2012	2/15/2013	40.61	0.2500%	0.2022%	40.61162

Scenario	Deal Date	Reference Date	USD/PHP	$F_{3,3}$
1	12/27/2012	3/27/2013	40.80	40.80
2	12/26/2012	3/26/2013	40.93	40.93
3	12/24/2012	3/25/2013	40.82	40.82
4	12/21/2012	3/22/2013	40.87	40.87
5	12/20/2012	3/21/2013	40.73	40.73
6	12/19/2012	3/20/2013	40.74	40.74
7	12/18/2012	3/19/2013	40.71	40.71
8	12/17/2012	3/18/2013	40.67	40.67

Figure 5: FX Forward: Monthly Forward Rates

4. Using the forward rates, the credit exposure per month $R_{j,t}$ are calculated for each scenario.

Scenario	Deal Date	Credit Exposure		
		t=1	t=2	t=3
1	12/27/2012	-0.40%	-0.89%	-0.80%
2	12/26/2012	-1.23%	-1.14%	-0.55%
3	12/24/2012	-1.21%	-0.99%	-0.76%
4	12/21/2012	-1.25%	-0.89%	-0.65%
5	12/20/2012	-1.21%	-1.15%	-0.90%
6	12/19/2012	-0.73%	-1.00%	-0.74%
7	12/18/2012	-1.24%	-1.07%	-0.90%
8	12/17/2012	-1.09%	-1.10%	-0.97%

Figure 6: FX Forward: Credit Exposure $R_{j,t}$

5. Finally, the PFE factor is obtained by taking the maximum of the absolute values of the 1st percentile and 99th percentile of the credit exposure each month using the `MAX(ABS(PERCENTILE()))` functions of Excel.

PFE Factor (3M)	
max(abs(1%),abs(99%))	4.0068%
PFE (USD)	**4.0068%**

PFE Factor (6M)	
max(abs(1%),abs(99%))	5.8129%
PFE (USD)	**5.8129%**

Figure 7: FX Forward: PFE Factor

3.3 Results and Discussion

The PFE factors obtained for the 3M and 6M FX forward contract are 4.0068% and 5.8129%, respectively. This indicates that in the span of the life of the forward contract, the value of the transaction can approximately increase or decrease by 4.00% and 5.81%, respectively, at a 99% confidence level. It is also worth noting that the 6M forward contract is riskier than the 3M forward contract. Overall, the results also indicate that the FX forward transactions exposes both parties to some degree of risk.