

MTH9845 Risk Management

Model Validation Report

with

Need-to-choose Pricing Model; Continue-the-Title

Submitted by

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Chapter 1

Executive Summary

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Chapter 2

Overview

2.1 Background and Recent Research

2.1.1 ;any sub section here;

2.1.2 Literature Survey

;Sub-subsection title;

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;Sub-subsection title;

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2.2 Motivation

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Chapter 3

Work Done

3.1 §Section title¿

3.1.1 §Sub-section title¿

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3.1.3 §Sub-section title¿

3.1.4 §Sub-section title¿

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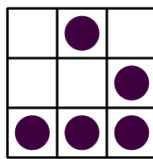


Figure 3.1: §Caption here¿

3.1.5 §Sub-section title¿

3.2 §Section title¿

Chapter 4

Test of Vanna-Volga Pricing

4.1 Data Source

4.1.1 Volatility Matrix

Volatility matrix data in terms of ATM, 10 Δ , and 25 Δ butterflies (BF) and risk reversals (RR) with three FX derivatives for Vanna-Volga models was sourced from Bloomberg. An example of volatility matrix data of EUR/USD observed on May 10, 2017 with 1M maturity was showing below. More volatility matrix data of other derivatives had been put in *Appendix 1*.

Exp	ATM Bid / Ask	25D RR Bid / Ask	25D BF Bid / Ask	10D RR Bid / Ask	10D BF Bid / Ask
1D	6.370 / 8.050	-0.500 / 0.675	-0.285 / 0.555	-0.855 / 1.160	-0.205 / 1.140
1W	6.010 / 6.835	-0.215 / 0.365	-0.040 / 0.370	-0.390 / 0.605	0.205 / 0.865
2W	5.915 / 6.400	-0.115 / 0.225	0.050 / 0.290	-0.320 / 0.365	0.315 / 0.705
3W	6.130 / 6.515	-0.010 / 0.260	0.095 / 0.285	-0.020 / 0.440	0.415 / 0.720
1M	6.975 / 7.250	-0.005 / 0.185	0.125 / 0.260	-0.020 / 0.310	0.460 / 0.680
2M	6.795 / 7.075	-0.185 / 0.010	0.160 / 0.300	-0.310 / 0.025	0.585 / 0.805
3M	6.795 / 7.065	-0.320 / -0.130	0.180 / 0.315	-0.545 / -0.220	0.655 / 0.870
4M	6.880 / 7.160	-0.410 / -0.215	0.190 / 0.330	-0.700 / -0.365	0.685 / 0.910
5M	6.957 / 7.204	-0.469 / -0.297	0.211 / 0.335	-0.810 / -0.513	0.759 / 0.959
6M	7.015 / 7.235	-0.520 / -0.365	0.230 / 0.340	-0.875 / -0.610	0.815 / 0.995
9M	7.135 / 7.345	-0.630 / -0.485	0.255 / 0.360	-1.070 / -0.820	0.920 / 1.085
1Y	7.215 / 7.420	-0.680 / -0.540	0.270 / 0.370	-1.175 / -0.930	0.980 / 1.140
18M	7.255 / 7.515	-0.600 / -0.415	0.260 / 0.390	-1.045 / -0.795	0.975 / 1.185
2Y	7.280 / 7.565	-0.545 / -0.345	0.260 / 0.400	-0.960 / -0.615	1.025 / 1.255
3Y	7.470 / 7.970	-0.375 / -0.025	0.200 / 0.450	-0.655 / -0.055	0.955 / 1.355
4Y	7.700 / 8.210	-0.185 / 0.170	0.190 / 0.445	-0.345 / 0.265	0.960 / 1.370
5Y	7.860 / 8.370	-0.185 / 0.170	0.190 / 0.445	-0.335 / 0.280	0.960 / 1.370

Figure 4.1: Volatility matrix data in the bid/ask format in terms of ATM, 10 Δ , and 25 Δ butterflies (BF) and risk reversals (RR), observed on May 10, 2017. Source: *Bloomberg*

In order to verify the price calculated by using Vanna-Volga model, two benchmark sources (Bloomberg pricing model and *investing.com* with price

provided by *Sentry Derivatives*) for all three FX derivatives had been put in *Appendix 1*. Since Vanna-Volga is an analytically derived correction to Black-Scholes model, the price calculated by Black-Scholes model also had been included for analysis.

The interest rates used for Vanna-Volga model and Black-Scholes model was obtained from *www.tradingeconomics.com* and listed in the following table.

Table 4.1: FX interest rates observed on May 10, 2017

Symbol	USD	EUR	GBP	JPY
Rates	1.00%	0.00%	0.00%	-0.10%

4.1.2 Model Implementation

As the volatility matrix obtained from Bloomberg is in the bid/ask format, the averaged mid volatility was used for Black-Scholes model and Vanna-Volga model. The mid volatility matrix data of three FX derivatives were list below. And we consider that live exchange rate as the initial price of FX options S_0 .

Table 4.2: Mid volatility matrix

FX derivatives	ATM	25D RR	25D BF	10D RR	10D BF	S_0
EUR/USD	7.1125	0.09	0.1925	0.145	0.57	1.0866
GBP/USD	6.7125	-0.28	0.2275	-0.4825	0.635	1.2933
USD/JPY	8.225	-0.4125	0.2225	-0.775	0.615	114.32

With the conventions and definitions specified in **Technical Specification**, the implementation of Black-Scholes model and Vanna-Volga model of FX derivatives had been coded in jupyter notebook with Python 3.5 in *Appendix 2*.

4.2 Testing Results

USD/GBP, USD/JYP, USD/EUR, historical interest rate, historical exchange rate, bloomberg 25delta Bloomberg: OVDL EUR/USD

price form: %EUR is price calculated (EUR Pips in *intesting.com*) divide
by S_0 : the exchange rate, i.e., $\%EUR = \frac{EURPips}{S_0}$

Chapter 5

Model Strengths and Weaknesses

5.1 Strengths

As we all known that Black-Scholes model is most often used to price vanilla options. However, the parameters used in Black-Scholes model are far from market quotations. The main reason is the unrealistic assumption that the volatility remain constant throught the lifetime of the vanilla options. Besides, the volatility surfaces of FX derivatives tend to be smile shaped or skewed. Thus, Black-Scholes model is insufficient in FX market.

There are models, such as Heston model and local volatility model, could capture and well replicate the smile shaped or skewed volatility surface of FX derivatives. However, none of them is easy to implement and require delicate calibration. Therefore, compare to other models used for FX derivatives, Vanna-Volga model has following strengths:

- Vanna-Volga is easy to implement, comparing to other models
- Vanna-Volga is simple and no or few calibration is needed
- Vanna-Volga is very efficient in computation, i.e., the calculation speed is significantly better than Heston model or local volatility model
- The instruments used for constructing the Vanna-volga model are very liquid in FX market. Typically, people are using straddle, risk reversal, and butterfly to construct Vanna-Volga framework

- Vanna-Volga is an analytically derived correction by capturing the greeks of vanna and volga to Black-Scholes model, i.e., by using vega, vanna and volga of the options. Therefore, it is easy to understand intuitively.

5.2 Weaknesses

Even though Vanna-Volga model also known as *trader's rule of thumb* and has some features listed above, it does have some drawbacks or conditions need to be understood before using it. Typical weaknesses of Vanna-Volga model are following:

- Vanna-Volga is precise when the maturity of options is up to 1 year, since the model assumes constant interest rates which does not lead to significantly mispricing for short maturity options in FX market.
- The application of Vanna-Volga model is limited to plain vanilla options and first-generation exotic options, such as barrier options, since it cannot fully replicate the volatility surface. However, many of the options in FX market is vanilla or first-generation exotic options.
- Vanna-Volga model perform well when the volatility surface is standard (such as smile shaped, typical skewed) of FX derivatives.

Chapter 6

Conclusion

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Acknowledgments

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References

- [1] ;Name of the reference here;, <urlhere>
- [2] ;Name of the reference here;, <urlhere>