[Graphs-Visualization-Service]

Studienarbeit

Eingereicht zur Teilerfüllung der Voraussetzungen für den Bachelor of Science in Informatik an der HSR

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Zeitraum: 18.09.2017 - 15.12.2017

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4.1 [Section Title]

[...] Between sections and subsections, you may want to add at least three or four sentences (or more), instead of leaving it blank.

4.1.1 [Subsection Title]

[...] In the next subsection, there is some sample text with figures and tables. [...]

4.1.2 Pricing Errors

[...] we present the root mean squared pricing errors (RMSEs) and the mean pricing errors (MPEs) on caps and swaptions implied volatilities, defined as the difference in percentage points between the model-implied values and the market-implied volatility quotes. Overall, we find that, for intermediate and long maturities, our model performs remarkably well. The cap pricing errors in Table 4.1 indicate that the model's performance suffers mostly at the short end of option maturities, especially for the one-year maturity. Short maturity contracts are underpriced by the model. However, the pricing performance considerably improves with increasing maturity. For longer maturities, a tendency exists to underprice out-of-the money and overprice in-the-money contracts.

For the ATM swaptions implied volatilities in Table 4.2, we observe a similar pattern. The model

Tabelle 4.1 – Pricing errors for the caps market.
Reported are sample averages of the root mean squared errors (RMSEs) and mean pricing errors (MPEs) for caps implied volatilities, defined as the difference in percentage points between the model-implied values and the market-implied volatility quotes. Each row represents one cap maturity, and columns represent the moneyness of the cap.

	RMSE					MPE				
Maturity	0.80	0.90	1.00	1.10	1.20	0.80	0.90	1.00	1.10	1.20
One year	16.86	18.62	20.15	20.30	22.03	-10.73	-11.08	-11.95	-12.32	-15.96
Two years	12.26	11.71	9.79	9.57	9.85	-8.64	-8.77	-6.99	-6.17	-7.01
Three years	8.78	6.75	4.75	4.19	4.02	-6.67	-5.15	-3.44	-2.52	-2.59
Four years	6.47	4.29	2.25	1.66	2.03	-4.81	-2.98	-1.40	-0.48	-0.06
Five years	4.98	2.94	1.35	1.26	2.18	-3.41	-1.67	-0.30	0.56	1.29
Six years	4.28	2.36	1.41	1.68	2.50	-2.63	-0.92	0.31	1.11	1.97
Seven years	3.91	2.16	1.71	2.08	2.71	-2.07	-0.38	0.74	1.48	2.25
Eight years	3.63	2.07	1.89	2.27	2.80	-1.71	-0.07	0.95	1.63	2.33
Nine years	3.48	2.09	2.04	2.42	2.88	-1.35	0.20	1.15	1.79	2.41
Ten years	3.37	2.15	2.18	2.54	2.95	-1.06	0.42	1.31	1.91	2.47

struggles mostly for short option maturities and short swaption tenors, an observation that also holds true for the non-ATM swaptions. However, across moneyness no clear pattern emerges in terms of over- and underpricing as is the case for in-the-money and out-of-the-money caps.

The substantially higher pricing errors for the caps and swaptions market at shorter maturities call for further investigation. Ultimately, the caps and swaptions markets must be closely connected, as they both originate from derivatives written on the forward LIBOR. However, during periods of extreme market turmoil, the two markets might exhibit different behaviors due to differences in how the uncertainty regarding the intensified liquidity situation in the interbank market propagates through the caps and swaptions markets. Therefore, we next analyze the behavior of the pricing errors across time to see whether the caps and swaptions market become disintegrated or whether they suffer from the same deficiencies.

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Tabelle 4.2 – Pricing errors for at-the-money (ATM) swaptions.
Reported are sample averages of the root mean squared errors (RMSEs) and mean pricing errors (MPEs) for ATM swaptions implied volatilities, defined as the difference in percentage points between the model-implied values and the market-implied volatility quotes. Each row represents one swaption maturity, and each column represents one swap tenor.

	RMSE							MPE						
	Swap tenor							Swap tenor						
Option maturity	One year	Two years	Three years	Four years	Five years	Seven years	Ten years	One year	Two years	Three years	Four years	Five years	Seven years	Ten years
Three months	21.16	9.66	4.46	4.82	5.94	8.30	10.32	-14.13	-7.24	-1.97	0.72	1.77	5.09	7.38
Six months	19.53	7.93	2.58	2.60	3.78	6.17	7.89	-13.67	-6.05	-1.45	0.90	1.93	4.35	6.10
One year	12.72	5.27	1.74	1.52	2.27	3.82	4.95	-8.81	-3.21	-0.43	0.86	1.48	2.83	3.84
Two years	4.20	2.20	1.49	1.31	1.36	1.61	2.04	-1.03	0.15	0.61	0.71	0.65	0.75	1.13
Three years	2.34	1.75	1.38	1.18	1.13	1.22	1.41	1.33	1.16	0.86	0.51	0.16	-0.05	-0.03
Four years	2.36	1.65	1.29	1.08	1.19	1.25	1.40	1.85	1.20	0.71	0.14	-0.17	-0.53	-0.65
Five years	2.36	1.65	1.35	1.25	1.32	1.51	1.67	1.89	1.13	0.49	-0.07	-0.47	-0.73	-0.88
Seven years	2.10	1.53	1.36	1.32	1.32	1.54	1.80	1.44	0.73	0.28	-0.16	-0.44	-0.74	-1.07
Ten years	1.93	1.56	1.40	1.39	1.42	1.53	1.72	1.32	0.88	0.50	0.22	-0.01	-0.47	-0.76

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4.1.3 A Note on Generating Figures

In Figure 4.1, we plot the time series of RMSE (Panel A) and the MPE (Panel B) for caps implied volatilities. We split the time series into long maturities and short maturities. For the first period of our data sample with the financial crisis already in full swing, the pricing errors in terms of RMSE remain remarkably low. In addition, until October 2008, we do not observe a bias in the model's pricing performance with the MPE close to zero. However, the pricing performance deteriorates considerably around April 2009 with substantial underpricing of short maturity contracts. This mispricing remains high until the end of our sample. Interestingly, this period of persistent mispricing of short maturity contracts coincides with the period of high implied volatilities at these maturities. Hence, our model suffers when the volatility term structure is unusually steep.

[...] If you use `PDF` files for input, you should run `PDFLATEX`. If you use `EPS` files, then run LaTeX,

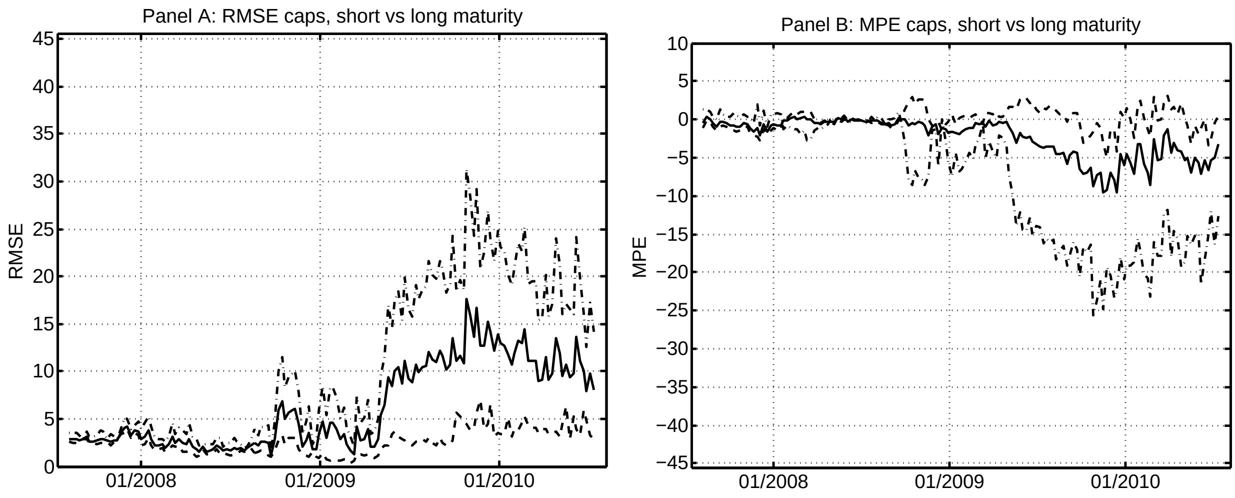

Abbildung 4.1 – Root mean squared error (RMSE) and mean pricing error MPE for caps with different option maturities. Panels A and B show the RMSE and the MPE in percentage points across time for caps implied volatilities of all maturities (solid line), for maturities up to three years (dash-dotted line), and for maturities of four to ten years (dashed line). Data are weekly (Wednesday) spanning our entire data sample August 8, 2007 to August 11, 2010; in total, 158 weeks.

then `DVI`→`PS`, then `PS`→`PDF`. To generate `PDF` files out of MATLAB, save them first as `EPS` files and then use the `DOS` prompt with the command `EPSTOPDF`. This gives the nicest results. Also, to generate MATLAB graphics in a decent format (lines will not get too thin and the labels will not get too small), use something like this:

```
figure(1)
set(gca,'Box', 'on', 'LineWidth',1.5 ,'FontSize',14)
plot(x,cumprod(1+R(:,2)),x,cumprod(1+R(:,3)),'--',x,cumprod(1+R(:,4)),'-.','LineWidth',1.5)
grid on
datetick('x','mmmyy')
axis([x(1)-10 x(end) 0.5 3.0])
title('Panel A: Equity and commodity indices')
ylabel('Cumulative return')
grid on
legend('MSCI World Total Return', 'MSCI Emerging Market Total Return','DJ UBS Commodity Index')
print('-depsc2', 'cumReturnA.eps' )
```

Whatever format you will eventually use, be sure that it looks nice and readable and use it consistently for the whole thesis.

4.1.4 A Note on Citations

[Here are some examples of citations...] Lévy processes cannot capture stochastic volatility, stochastic risk reversal (skewness) and stochastic correlation. These drawbacks can be resolved, at least to some extent, by considering time-changed Lévy processes for which it is possible to generate distributions which vary over time. If the return innovation is modeled by a Brownian motion, we can let the instantaneous variance be stochastic (see, e.g., Heston (1993) and Bates (1996)) to create dependence of the return increments.[1]

[1] Carr and Wu (2004), for instance, introduced a time-changed Lévy model to capture the leverage effect.

Anhang

Anhang A

Proofs

[You may also want to add an appendix, if it makes sense. You delegate proofs to the appendix or other material that is essential for the understanding of your work, but would distract the reader if placed in the main text...]

A.1 Proof of Proposition [...]

[....], we can apply Ito's formula for Lévy processes to obtain the dynamics of the forward LIBOR $L(t, T_j)$ to obtain the dynamics of the forward LIBOR $L(t, T_j)$ under the T_{j+1}-forward measure as follows:

$$\begin{aligned} \frac{dL(t,T_j)}{L(t,T_j)} &= b(t,T_j,T_{j+1})dt + \frac{1}{2}\lambda^2(t,T_j)dt + \frac{1}{2}V_t^W dt \\ &+ \int_{-\infty}^{0} [e^x - 1 - x]\, \pi_{J^-}^{\mathbb{Q}_{j+1}}(dx)\nu_t^J dt + \int_{0}^{\infty} [e^x - 1 - x]\, \pi_{J^+}^{\mathbb{Q}_{j+1}}(dx)\nu_t^J dt \\ &+ \lambda(t,T_j)dB_t^{Q_{j+1}} + \sqrt{V_t^W}dW_t^{Q_{j+1}} + \int_{-\infty}^{0} [e^x - 1]\left[\mu^-(dt,dx) - \pi_{J^-}^{Q_{j+1}}(x)dx\nu_t^J dt\right] \\ &+ \int_{0}^{\infty} [e^x - 1]\left[\mu^+(dt,dx) - \pi_{J^+}^{Q_{j+1}}(x)dx\nu_t^J dt\right]. \end{aligned} \tag{A.1}$$

To ensure that $L(t, T_j)$ is a martingale under the T_{j+1}-forward measure, the drift must equal zero, which gives the drift condition in the proposition. ■

Literaturverzeichnis

D. S. Bates. Jumps and stochastic volatility: Exchange rate processes implicit in Deutsche Mark options. *Review of Financial Studies*, 9(1):69–107, 1996.

P. Carr and L. Wu. Time-changed Lévy processes and option pricing. *Journal of Financial Economics*, 71(1):113–141, 2004.

S. L. Heston. A closed-form solution for options with stochastic volatility with applications to bond and currency options. *Review of Financial Studies*, 6(2):327–343, 1993.

Eidesstattliche Erklärung

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