
The Success of Structured Financial Products in Switzerland: The Case of Multi Reverse Convertibles with Barrier Protection

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Structure

1. Why are MBRC Interesting?
2. Overview of the Swiss Market of Structured Products
3. Types of Reverse Convertibles
4. Literature Review
5. Theoretical and Numerical Valuation
6. Empirical Analysis of Pricing in the Primary Market

Interview *Finanz und Wirtschaft* with Myron Scholes

Nobelpreisträger Myron Scholes über Risikotransfer, Hedge Funds, innovative Kreditderivate und Zertifikate

Finanz und Wirtschaft 18.07.2007 , Ausgabe: 56 , Seiten: 45 , Rubrik: Z-DERIVATE

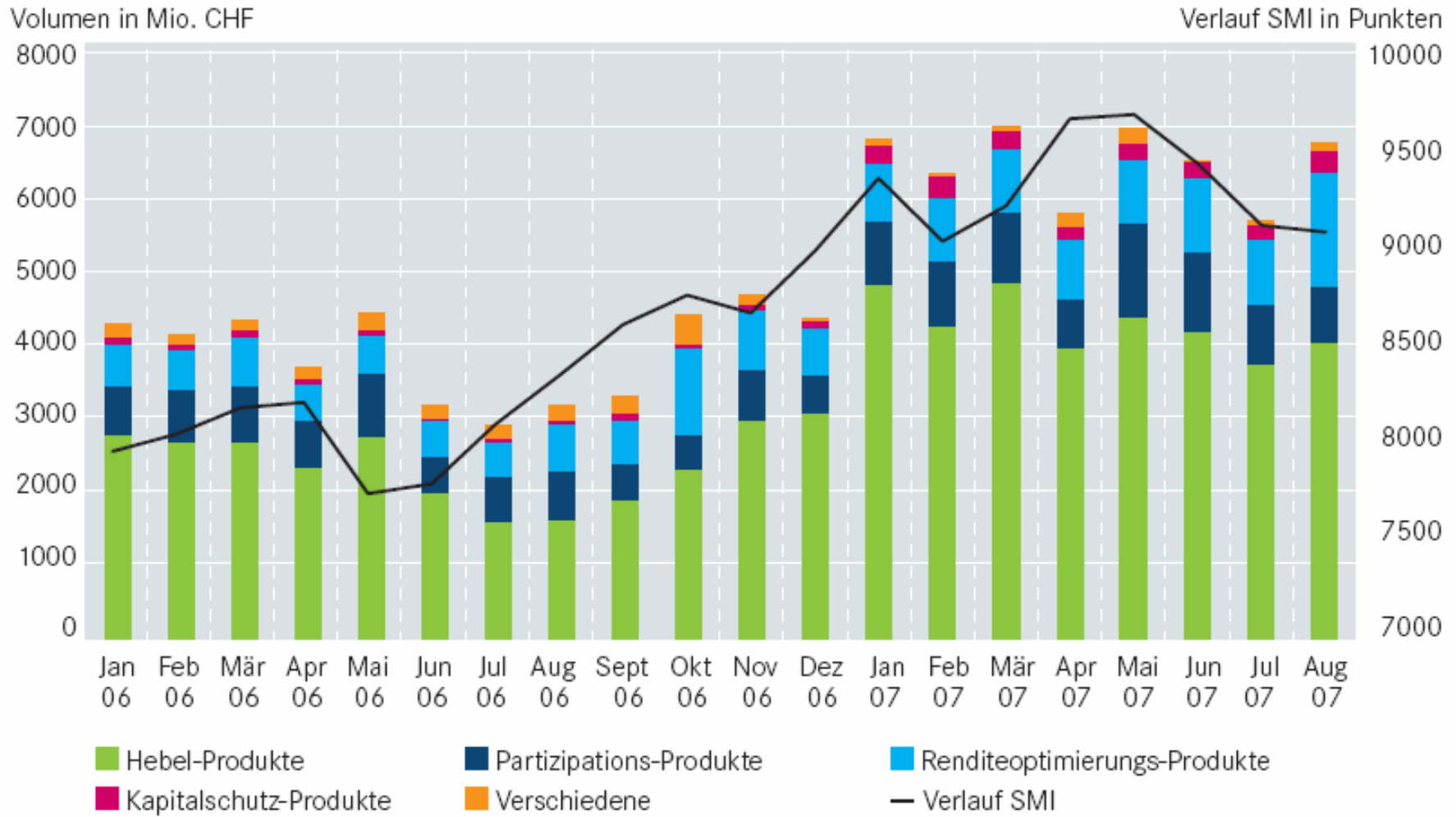
In Europa boomen strukturierte Produkte. Ist dieses Instrument nützlich?

Aus strategischer Sicht ist das eine phänomenale Innovation. Früher verkauften Finanzintermediäre den Investoren einzelne Instrumente, beispielsweise Obligationen. Dann stellten sie daraus Portefeuilles zusammen und boten den Kunden Anteile mit unterschiedlichem Risiko-Rendite-Profil an. Jetzt fragen die Intermediäre: Welches Risiko-Rendite-Profil wollen Sie? Und das strukturieren sie dann massgeschneidert. Das ist viel effizienter, als wenn ein Anleger auf eigene Faust Aktien und Optionen kombiniert.

Weshalb sind strukturierte Produkte in den USA nicht erfolgreich?

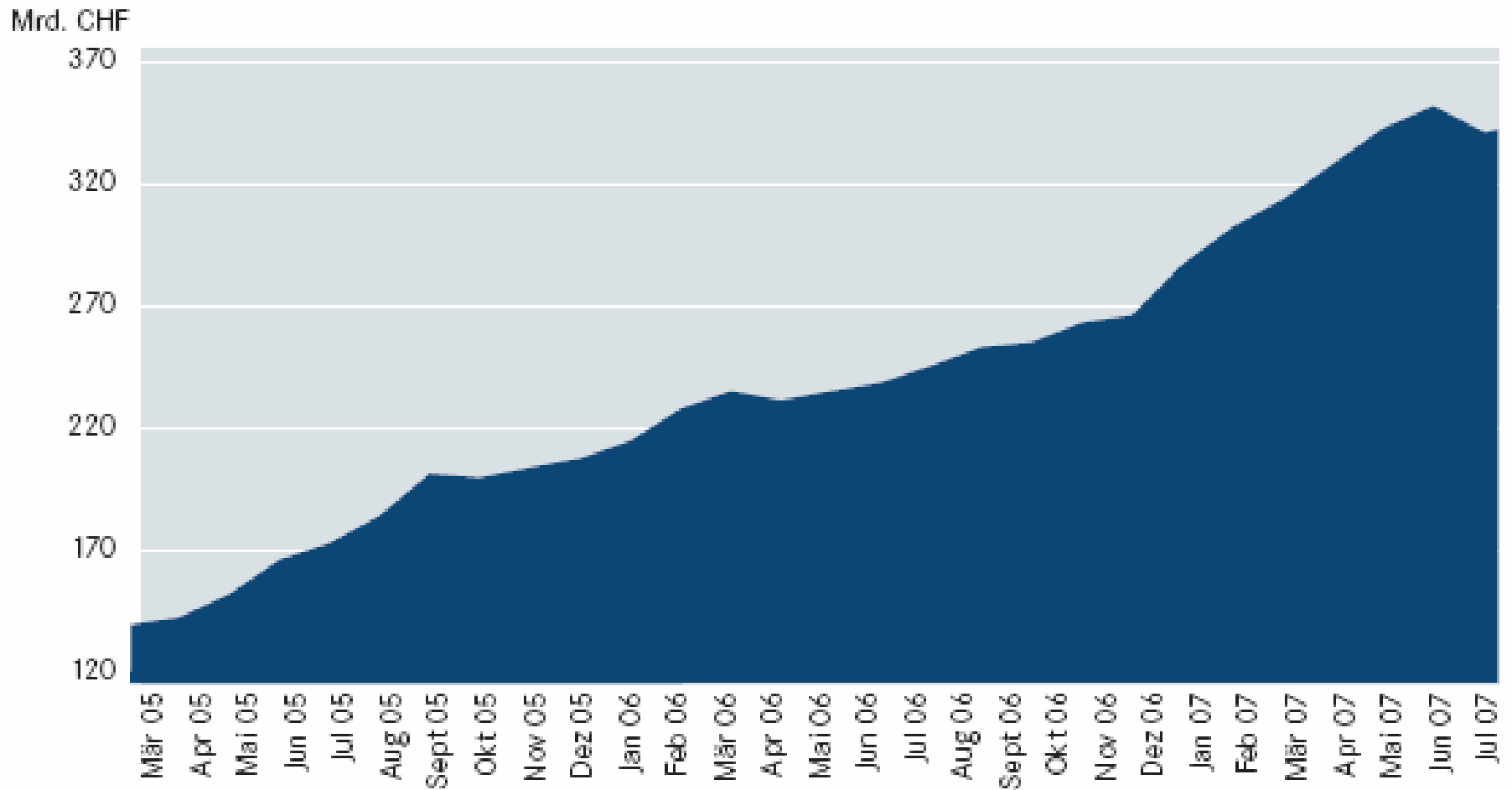
Ich gebe zu, dass auch Europa Innovationen hervorbringt – doch Spass beiseite: Möglicherweise blockiert die Regulierung in den USA die Entwicklung. Es scheint ähnlich zu sein wie im Fussball: In Europa lässt der Schiedsrichter das Spiel laufen und interveniert seltener, im American Football pfeift er viel öfter.

Trading volume of structured products listed at Scoach



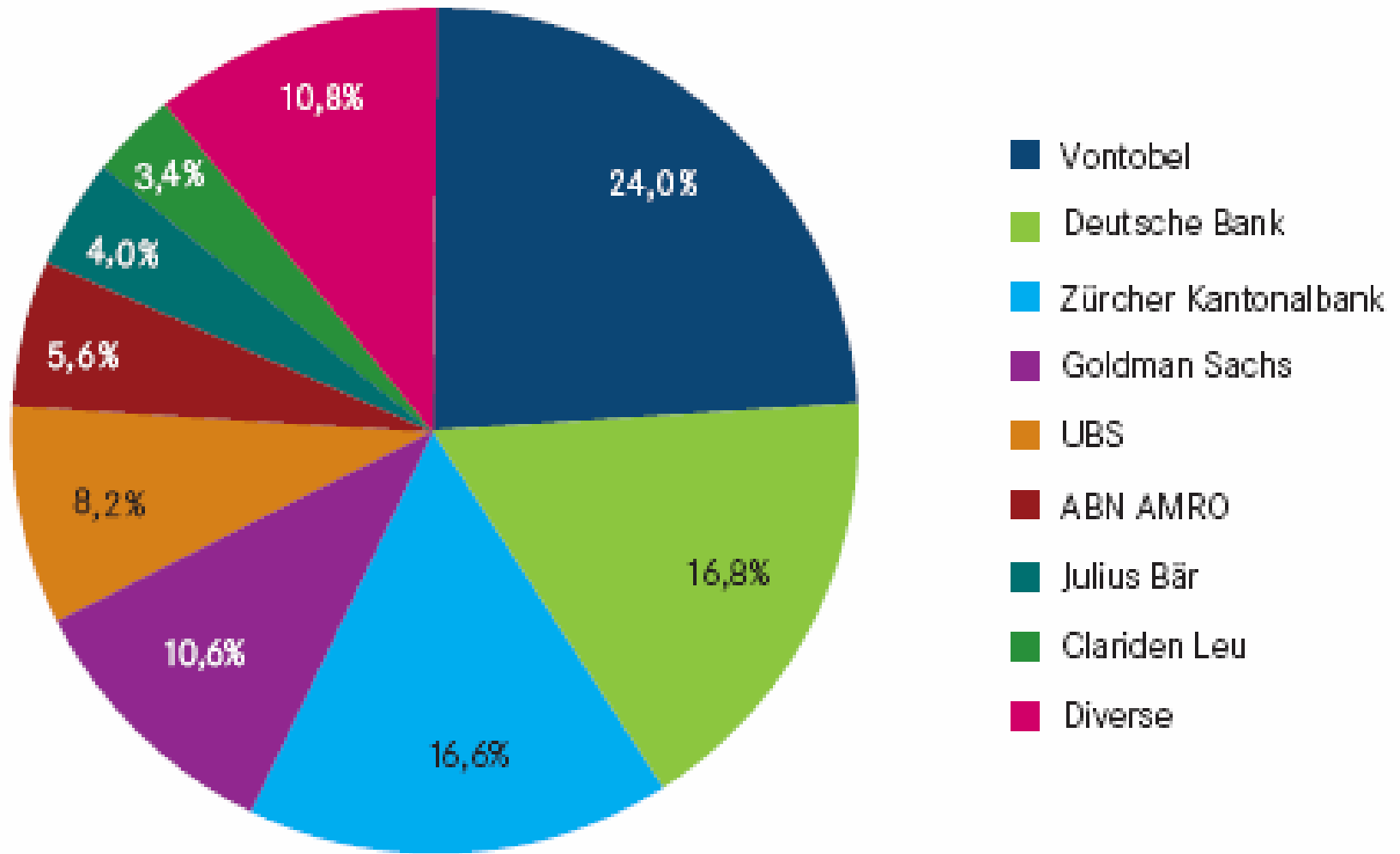
Source: SWX and Derivative Partners AG.

Amounts invested in structured products in Swiss securities accounts



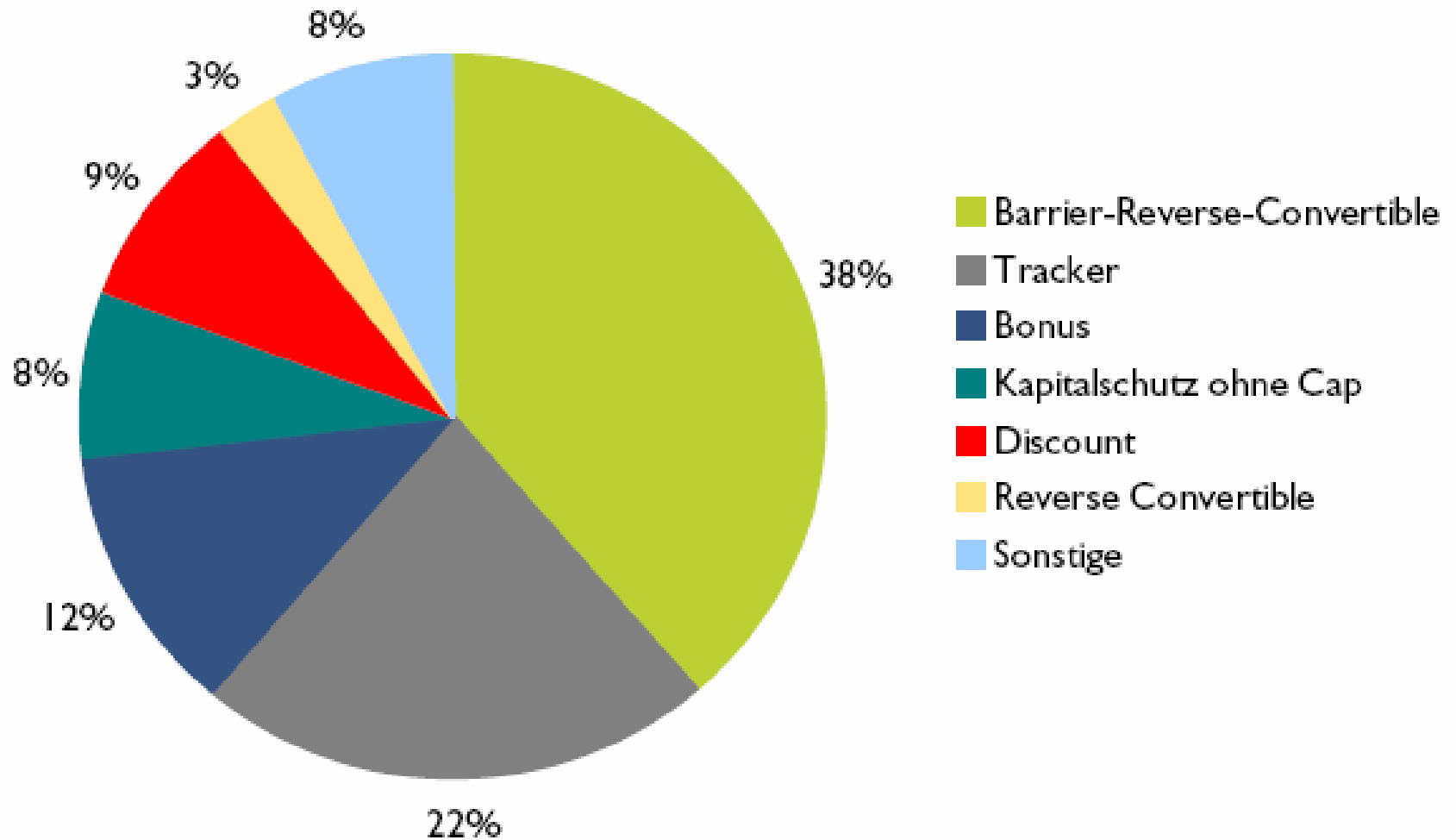
Source: SWX and Derivative Partners AG.

Share of trading volume at Scoach by issuers



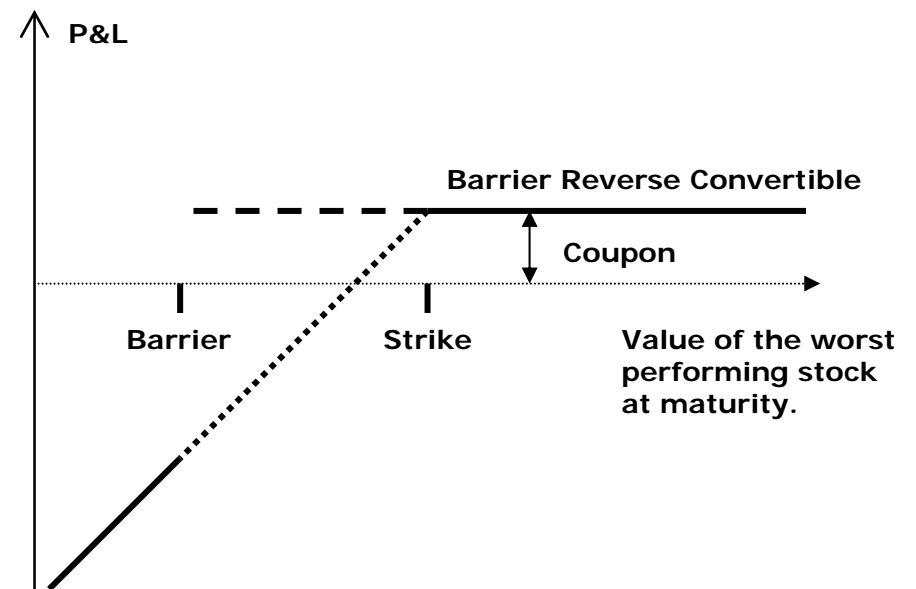
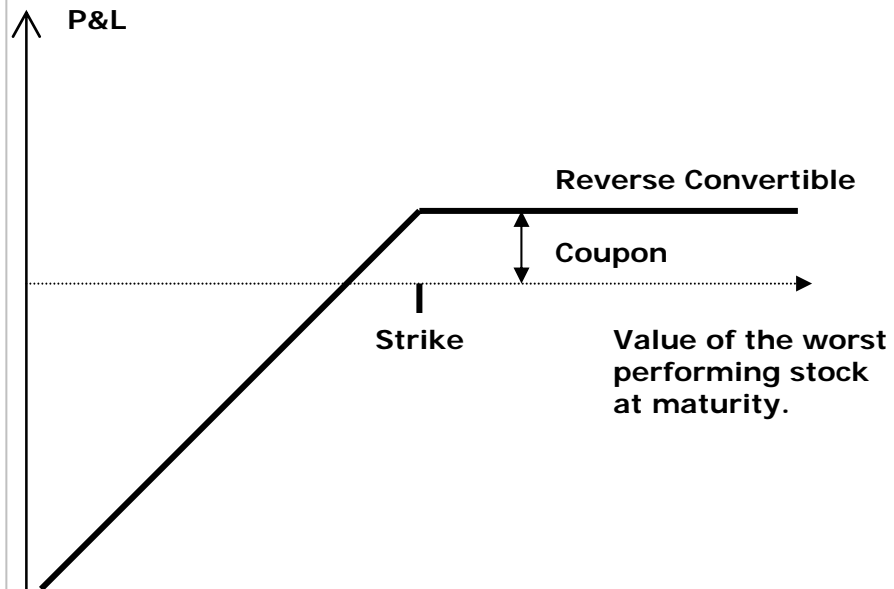
Source: SWX and Derivative Partners AG.

Types of products listed at Scoach (end of June 2007)



Source: SWX and Derivative Partners AG.

Profit and loss profile reverse convertibles



Repayment of Multiple Barrier Reverse Convertibles

Each Certificate entitles the holder, in accordance with the respective Terms and Conditions of the Certificates, to receive on the Repayment Date an amount equal to:

- (i) If the Underlying Prices (i) of any of the Underlyings (i) have not been equal to or lower than the respective Barrier Levels (i) at any time during the Observation Period:

Nominal

- (ii) If the Underlying Price (i) of at least one of the Underlyings (i) was equal to or lower than the Barrier Levels (i) at least once during the Observation Period **and** all Reference Prices (Final) (i) are above the respective Reference Prices (Initial) (i):

Nominal

- (iii) If the Underlying Price (i) of at least one of the Underlyings (i) was equal to or lower than the Barrier Levels (i) at least once during the Observation Period **and** if at least one Reference Prices (Final) (i) is lower than or equal to the Reference Price (Initial) (i):

The Redemption (i) of the Underlying (i) which has the highest negative performance (measured by Reference Price (Final) (i) divided by Reference Price (Initial) (i)), subject to further definitions as set out in the Terms and Conditions of the Certificates

Excerpt from term sheet Goldman Sachs.

Previous empirical studies

- Benet, B.A./Giannetti, A./Pissaris, S. (2006): Gains from structured product markets: The case of reverse-exchangeable securities (RES), in: *Journal of Banking and Finance* 30, 111-132.
- Burth, S./Kraus, T./Wohlwend, H. (2001): The pricing of structured products in the Swiss market, in: *Journal of Derivatives* 8 (Winter), 30-40.
- Grünbichler, A./Wohlwend, H. (2005): The valuation of structured products: Empirical findings for the Swiss market, in: *Financial Markets and Portfolio Management* 19, 361-380.
- Hernandez, R./Lee, W.Y./Liu, P. (2007): An economic analysis of reverse exchangeable securities - An option-pricing approach, Working Paper University of Arkansas.
- Stoimenov/Wilkens (2005): Are structured products 'fairly' priced? An analysis of the German market for equity-linked instruments, in: *Journal of Banking and Finance* 29, 2971-1993.
- Szymanowska, M./Horst, J.T./Veld, C. (2007): Reverse convertible bonds analyzed, Working Paper University Rotterdam.
- Wasserfallen, W./Schenk, C. (1996): Portfolio insurance for the small investor in Switzerland, in: *Journal of Derivatives* 3 (Spring), 37-43.
- Wilkens, S./Erner, C./Röder, K. (2003): The pricing of structured products in Germany, in: *Journal of Derivatives* 10 (Fall), 55-68.

Literature review

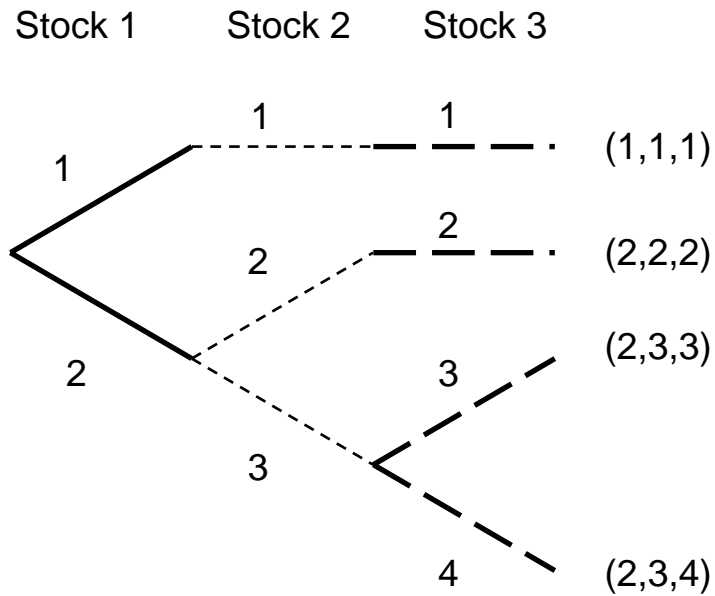
BKW (01)	Reverse convertibles and discount certificates on single Swiss stocks. In average 1.91% overvalued in primary market.
WER (03)	Secondary market, on single German stocks. Average overvaluation of 3.04% and 4.20% for reverse convertibles and discount certificates, respectively. Life cycle hypothesis: Premium is highest at issuance, declines over the product's lifetime and turns negative near expiry.
GW (05)	Implied volatilities lower than those of plain vanilla Eurex options. 4.25 percentage points on primary market, 1.65 percentage points on secondary market. Exotic products and reverse convertibles are significantly more overvalued than discount certificates.
SW (05)	Different types of exotic products on primary and secondary German market. Overvaluation is higher for barrier products (4.77%) and rainbow products (5.17%) than for standard products (3.89%).
BGP (06)	First study in USA, 31 reverse convertibles. Average coupon is 4% to 6% lower than its theoretical fair value.
SHV (07)	Primary Dutch market. Overvaluation of reverse convertible by more than 5%. Undervaluation of barrier products.
HLL (07)	Large sample in Europe, 1998-2007. Average overpricing of 4.69%. More complex products are more overvalued.

Valuation: Boyle/Evnine/Gibbs (1989)

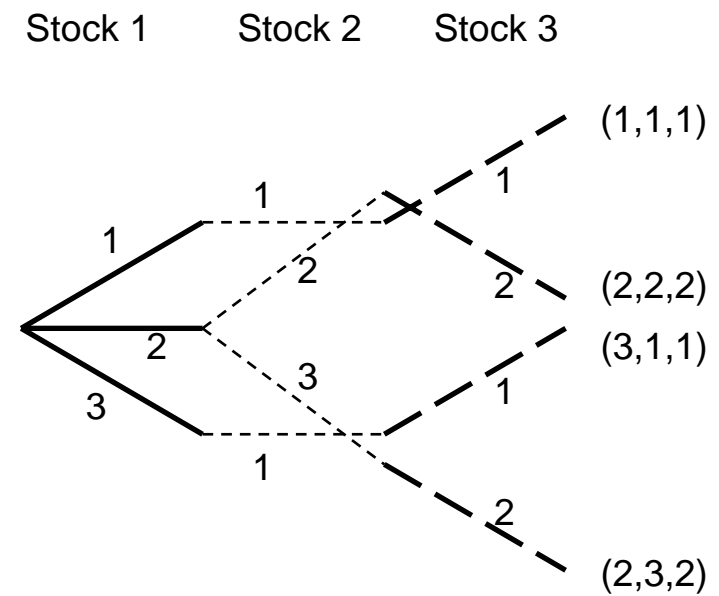
- n -dimensional binomial tree as a discrete approximation for the n -dimensional multivariate lognormal distribution.
- Equate characteristic functions for the multivariate normal and the discrete multivariate distribution.
- Financial market in this model not complete.
- For n assets after s time steps: $(s + 1)^n$ nodes.

Stock price tree proposed by Chen/Chung/Yang (2002)

Chen/Chung/Yang (2002)



Alternative of Rathgeber (2005)



1st step: Define 3 independent basic processes

z^k : n -vector of possible values of process k at the end of next time step

p : n -vector of probabilities, that state $1, \dots, n$ occurs.

$$\begin{aligned}(z^k)' p &= 0 \quad \forall k \\(z^k \circ z^k)' p &= 1 \quad \forall k \\(z^k \circ z^l)' p &= 0 \quad \forall k \neq l\end{aligned}$$

Two possible settings $Z = (z^1, z^2, z^3)$

(Rathgeber (2005) vs. Chen/Chung/Yang(2002)):

$$Z^R = \begin{pmatrix} \sqrt{2} & 0 & 1 \\ -\sqrt{2} & 0 & 1 \\ 0 & -\sqrt{2} & -1 \\ 0 & \sqrt{2} & -1 \end{pmatrix}; \quad Z^C = \begin{pmatrix} \sqrt{3} & 0 & 0 \\ -\frac{\sqrt{3}}{3} & 2 \cdot \sqrt{2/3} & 0 \\ -\frac{\sqrt{3}}{3} & -\sqrt{2/3} & \sqrt{2} \\ -\frac{\sqrt{3}}{3} & -\sqrt{2/3} & -\sqrt{2} \end{pmatrix}$$

2nd step: Transformation to stock price processes

A : Cholesky decomposition of the asset returns' covariance matrix

$$X = Z \cdot A + EE$$

where

$$EE = \begin{pmatrix} E^1 & E^2 & E^3 \\ \vdots & \vdots & \vdots \\ E^1 & E^2 & E^3 \end{pmatrix}_{(4 \times 3)}$$

E^k : expected rate of return of asset k .

$$1 = e^{-r} \left[q_1 e^{x_1^1} + q_2 e^{x_2^1} + q_3 e^{x_3^1} + q_4 e^{x_4^1} \right]$$

$$1 = e^{-r} \left[q_1 e^{x_1^2} + q_2 e^{x_2^2} + q_3 e^{x_3^2} + q_4 e^{x_4^2} \right]$$

$$1 = e^{-r} \left[q_1 e^{x_1^3} + q_2 e^{x_2^3} + q_3 e^{x_3^3} + q_4 e^{x_4^3} \right]$$

$$1 = q_1 + q_2 + q_3 + q_4.$$

How to take account of the barrier characteristic

- See Cox/Rubinstein (1985).
- Backward calculation through the tree is done twice:
 - **Main calculation** starts from the assumption that the barrier has not been broken,
 - **Additional calculation** based on put option knocked-in.
- If the barrier is broken at a node of the main calculation, the node's value is replaced by the corresponding value from the additional calculation.

Not taken into account:

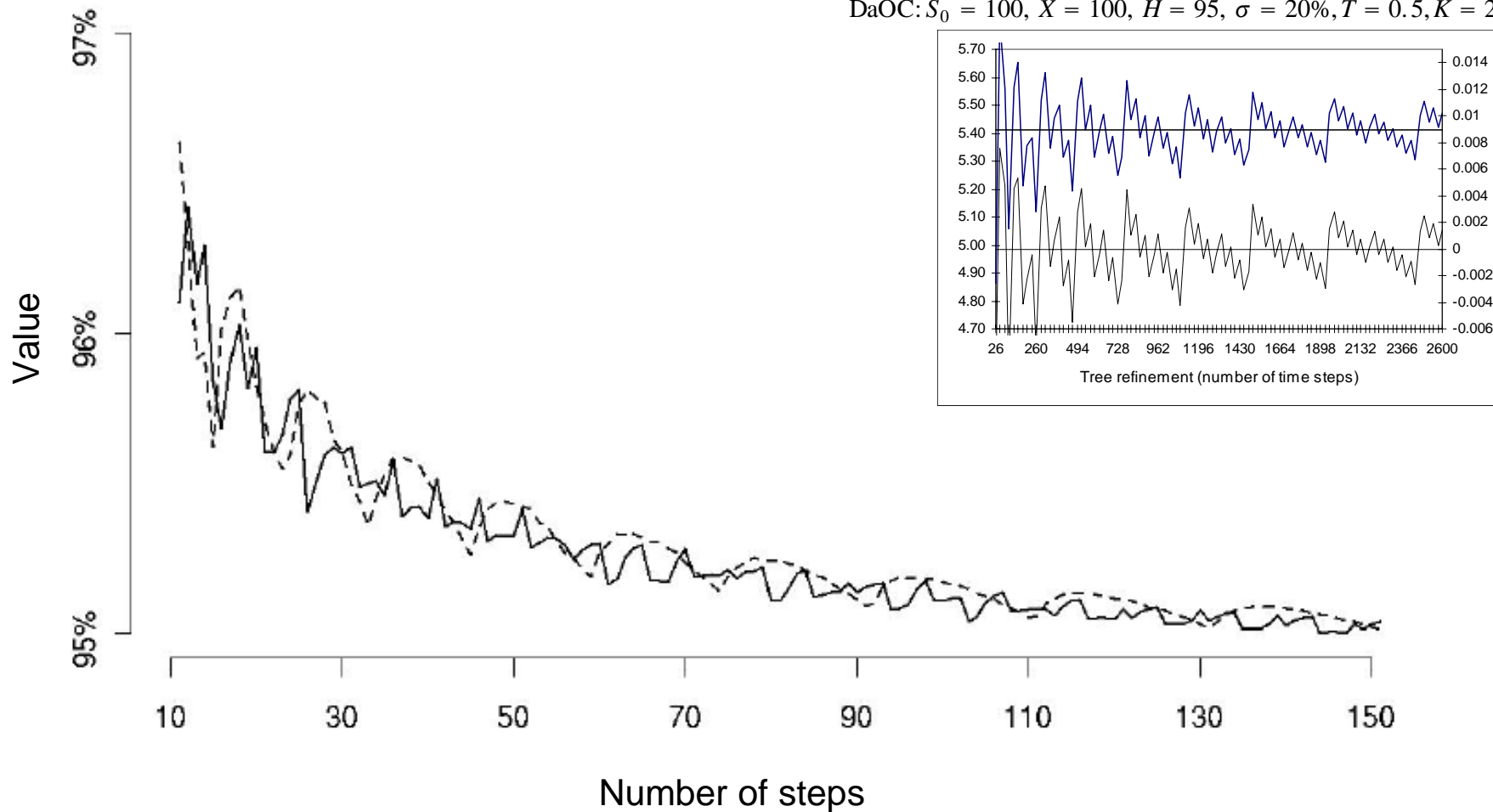
- Stochastic volatilities,
 - Jumps in the asset price processes,
 - Market frictions,
 - Stochastic correlations,
 - „Break-down“ of correlations in market crises.
-
- But: Theoretical prices from Black-Scholes framework can be interpreted as upper bounds of fair prices. → Overpricing is underestimated.

Example

Parameter	Value
Time to Maturity	1 year
Coupon	11% p.a., 2 payments per year
Continuous Risk Free Rate	3% p.a.
Dividend Yield	1% for all underlyings
Dividend Payment Underlying 1	After 3 months
Dividend Payment Underlying 2	After 6 months
Dividend Payment Underlying 3	After 9 months
Barrier Level	75% for all underlyings
Volatilities (Underlyings 1, 2, 3)	23%, 29%, 32%
Correlation Underlyings 1, 2	0.27
Correlation Underlyings 1, 3	0.50
Correlation Underlyings 2, 3	0.39

Convergence

DaOC: $S_0 = 100$, $X = 100$, $H = 95$, $\sigma = 20\%$, $T = 0.5$, $K = 26$



Solid line: Specification of Chen/Chung/Yang (2002),
broken line: specification of Rathgeber (2005).

Data

- Termsheets of 751 TBRC with stocks as underlyings, outstanding in April 2007 on the Swiss market.
- Dividend yields of 2006 are assumed to remain constant.
- 12 month interbank offered rates in the corresponding currency used as risk-free rates of return.
- Bond yields of issuer: risk-free rate of return adjusted for credit spread of corresponding rating class.
- Eurex settlement data for the calculation of implied volatilities.
- Two-step interpolation to match the moneyness and maturity dates of TBRC and Eurex options.
- Historical correlation from daily returns over the last year.

Issuers and product names

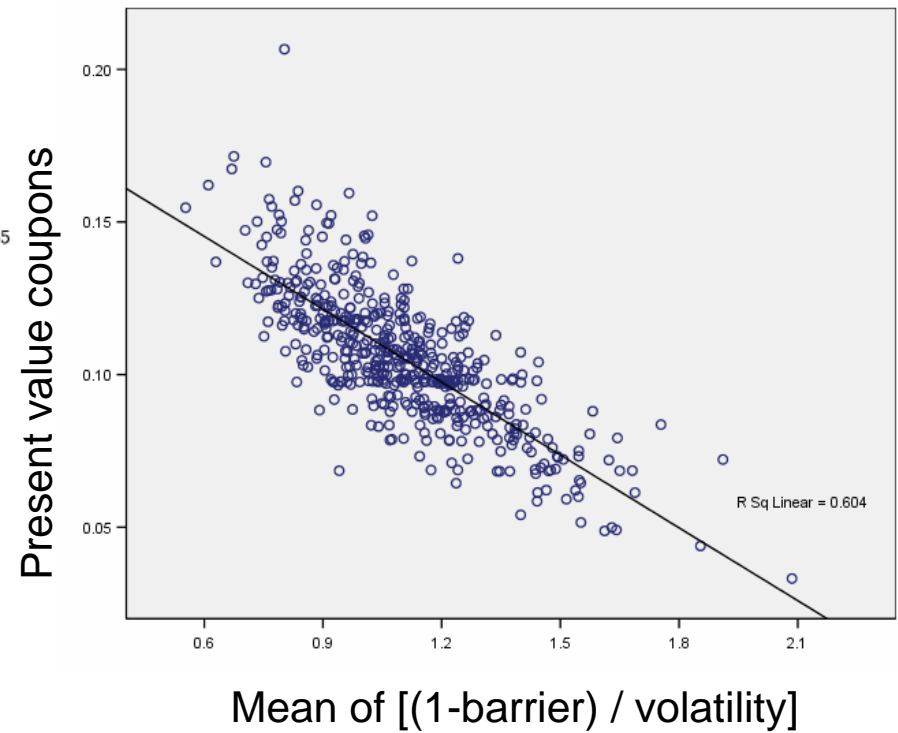
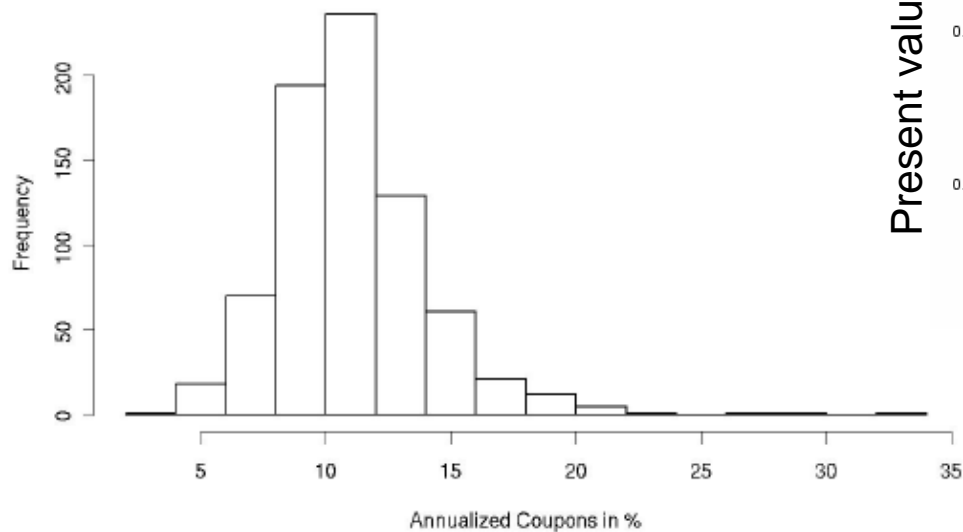
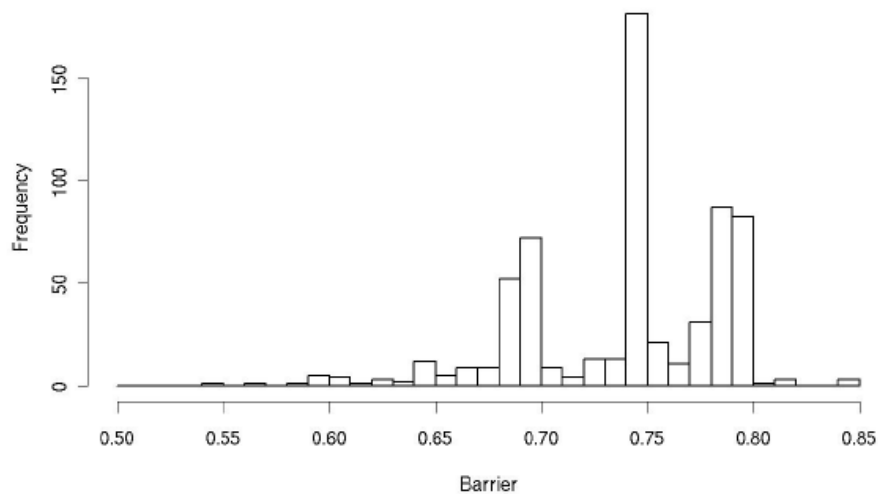
Issuer	Product Name	Approx. Number of Products Outstanding
UBS AG	Kick-In GOAL on Worst of	218 (165)
Clariden Leu	Multi Barrier Reverse Convertible	168 (151)
Julius Bär	Triple ICE Unit	100 (100)
Goldman Sachs	Multi Barrier Reverse Convertible	94 (87)
Bank Vontobel	Multi Defender Vonti	67 (66)
Zürcher Kantonalbank	Soft-Runner on Worst of	54 (54)
Merrill Lynch	Callable Worst of Kick-in Reverse Convertible	35 (31)
Bank Sarasin	SaraSail Rainbow mit Barriere	32 (31)
Banque Cantonale Vaudoise	LEMAN DEFENSIF WORST OF	29 (29)
Sal. Oppenheim	BARRIER-TRIPLE- REVERSE-CONVERTIBLE	18 (18)
Citigroup	Barrier Reverse Convertible	17 (17)
Lehman Brothers	Barrier Reverse Convertible Certificate on Worst of	2 (2)
Total		834 (751)

Underlying assets and size of market

Asset	Used in # products	Country	Part of Underlyings
Roche Holding	169	Switzerland	67.11%
Credit Suisse Group	132	Germany	10.03%
ABB	123	USA	9.28%
UBS	122	Great Britain	3.95%
Novartis	120	France	3.95%
Nestlé	117	Netherlands	1.64%
Zurich Financial Services	115	Italy	0.93%
		Canada	0.93%
		Others	2.18%

Currency	Amount in Local Currency	Amount in CHF
CHF	14'705'000'000	14'705'000'000
EUR	2'615'000'000	4'328'000'000
USD	906'000'000	1'112'000'000
GBP	127'000'000	308'000'000
JPY	7'800'000'000	79'000'000
CAD	50'000'000	56'000'000
AUD	40'000'000	40'000'000
Total		20'628'000'000

Coupons and barrier levels (TBRC with $T=1$ year)

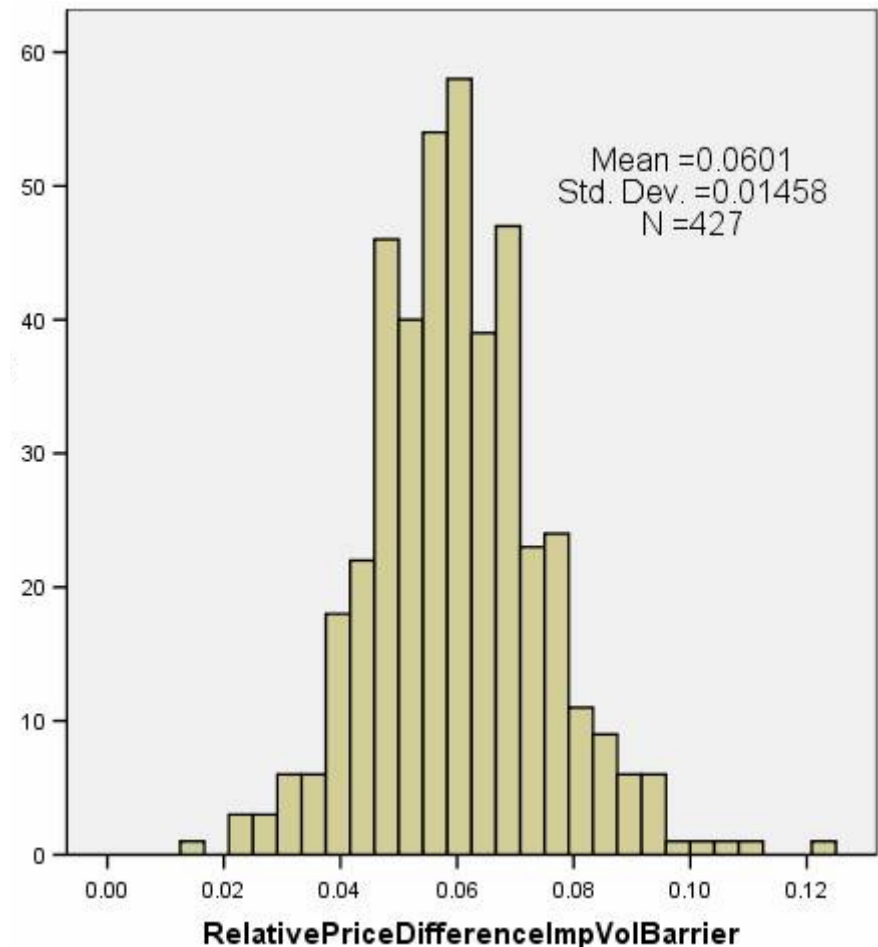
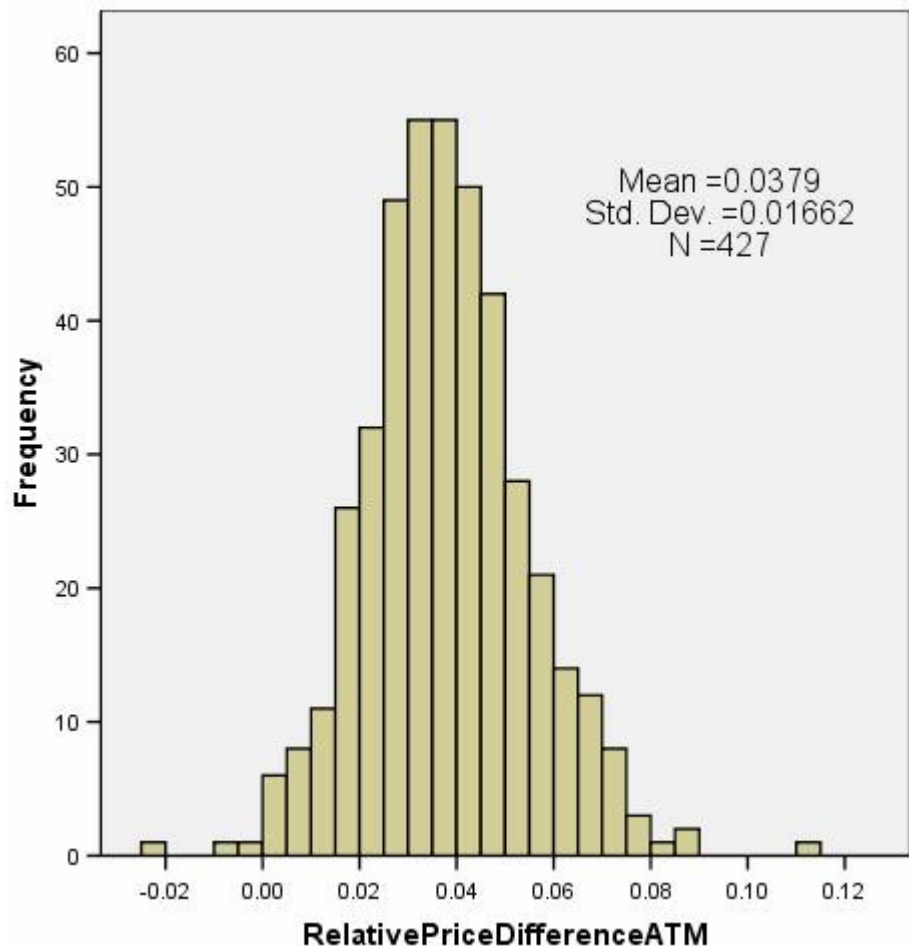


Hypotheses

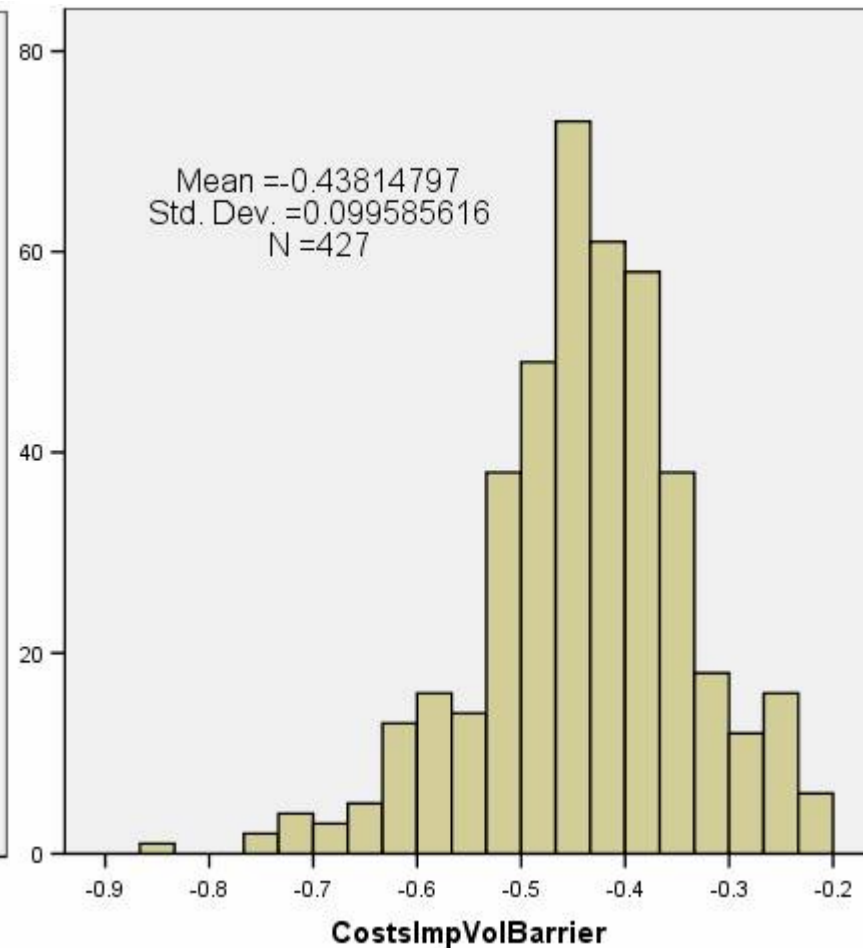
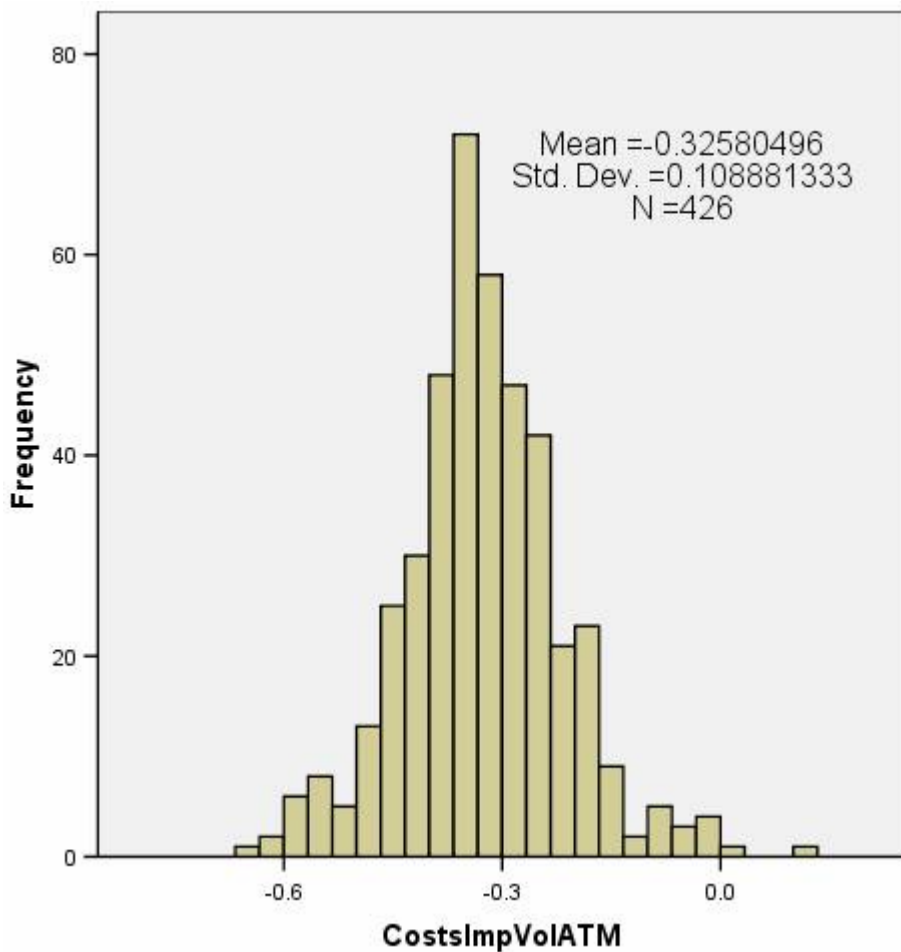
1. Triple Barrier Reverse Convertibles are, on average, priced above their theoretical values and thus favor the issuing bank.
2. The overpricing at issuance is more pronounced for TBRC than for less complex products.
3. The overpricing is higher if the issuer does not have an own distribution channel in Switzerland.
4. The overpricing is less pronounced for products with the same set of underlying assets as already existing TBRC.
5. Underlyings with high dividend yields are preferred by issuers, and the overpricing is higher if the underlying assets have high dividend yields.
6. The overpricing is higher for products with high coupons.
7. The overpricing is higher for high volatilities and low correlations of underlying assets.

Distributions of relative price deviations

$$\Delta V_i = \frac{P_i^{Market} - P_i^{Theory}}{P_i^{Theory}}$$



Distributions of relative price deviations of embedded put



Relative price deviations by issuer

	Mean	Median	Minimum	Maximum	Std. Deviation	Stand. Error of Mean	N
Bank Sarasin	0.0296	0.0287	0.0013	0.0621	0.0129	0.0029	28
Bank Vontobel	0.0303	0.0289	-0.0232	0.0636	0.0175	0.0026	60
Banque Cantonale Vaudoise	0.0385	0.0392	0.0018	0.0543	0.0116	0.0025	28
Citigroup	0.0469	0.0453	0.0320	0.0694	0.0094	0.0023	17
Clariden Leu	0.0417	0.0428	-0.0061	0.0806	0.0167	0.0019	149
Goldman Sachs	0.0402	0.0416	0.0063	0.0789	0.0141	0.0024	68
Julius Baer	0.0352	0.0332	0.0126	0.0729	0.0135	0.0018	90
Merrill Lynch	0.0289	0.0227	0.0032	0.0893	0.0266	0.0084	27
Sal. Oppenheim	0.0465	0.0512	0.0238	0.0706	0.0146	0.0046	14
UBS	0.0390	0.0366	0.0030	0.1107	0.0194	0.0020	149
Zürcher Kantonalbank	0.0386	0.0374	0.0192	0.0719	0.0122	0.0020	51

Regression approach

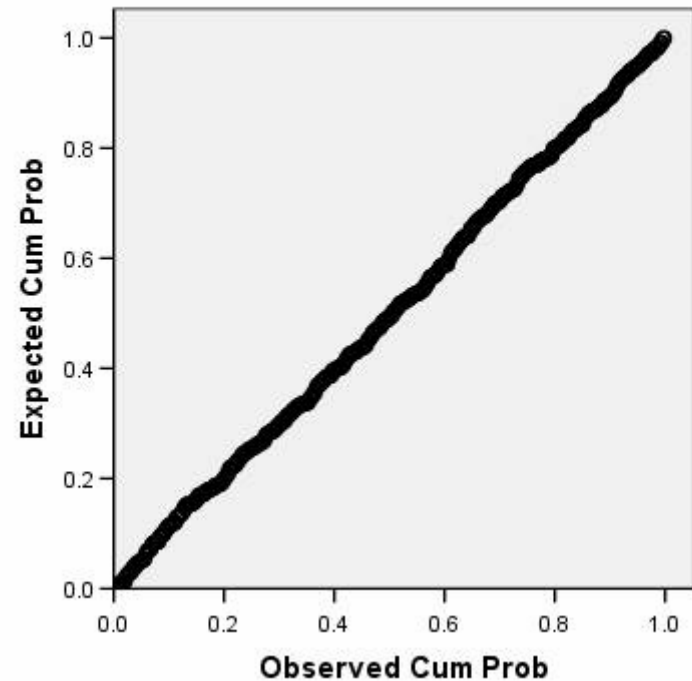
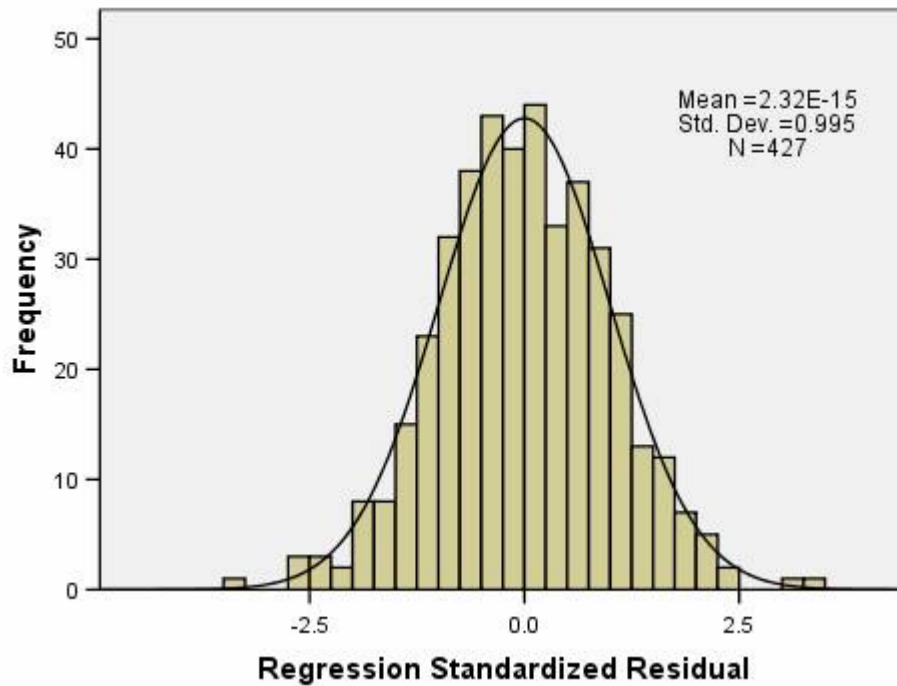
$$\text{Relative Price Deviation} = \alpha + \beta_1 \cdot \text{PV Coupon} + \beta_2 \cdot \text{Mean Dividend Yield} \\ + \beta_3 \cdot \text{Mean Correlation} + \beta_4 \cdot \text{Mean Volatility} + \epsilon$$

	stand. coeff.	t-stat	p-value
PV Coupon	-0.0140	-0.2577	0.7968
Mean Dividend Yield	0.1134	2.1171	0.0348
Mean Correlation	-0.2816	-5.8829	<0.0001
Mean Volatility	0.4968	7.5307	<0.0001

Adjusted R-squared = 0.183

Residual analysis

Normal P-P Plot of Regression Standardized Residual



Underlying assets ABB, CS Group and Roche

Issuer	Fixing	Maturity date	Barrier	PV Coupon	ImpVolATM1	ImpVolATM2	ImpVolATM3
ml	18.08.2006	24.08.2007	0.632	0.098	0.338	0.239	0.218
ubs	17.10.2006	17.10.2007	0.75	0.119	0.283	0.227	0.208
ubs	15.12.2006	14.12.2007	0.75	0.133	0.293	0.227	0.195
gs	20.12.2006	20.12.2007	0.79	0.129	0.301	0.231	0.195
bcv	18.01.2007	19.01.2008	0.75	0.117	0.308	0.245	0.208
ubs	23.01.2007	25.01.2008	0.7	0.100	0.308	0.243	0.210
citi	12.02.2007	12.02.2008	0.8	0.131	0.286	0.234	0.211
gs	05.03.2007	05.03.2008	0.67	0.081	0.295	0.246	0.216
ubs	04.04.2007	04.04.2008	0.74	0.118	0.273	0.251	0.200

Issuer	Corr12	Corr13	Corr23	Rel. Price Dev. ATM	Rel. Price Dev. ImpVol	Barrier
ml	0.622	0.279	0.301	0.006		0.047
ubs	0.634	0.292	0.297	0.026		0.048
ubs	0.673	0.274	0.279	0.010		0.032
gs	0.671	0.283	0.282	0.036		0.047
bcv	0.664	0.283	0.293	0.043		0.061
ubs	0.660	0.288	0.295	0.032		0.058
citi	0.668	0.326	0.353	0.038		0.046
gs	0.668	0.352	0.366	0.029		0.057
ubs	0.683	0.389	0.417	0.020		0.040

Mean

0.027

0.048