ELTE TTK Valószínűségelméleti és Statisztika Tanszék
Szakdolgozati témák 2016/2017
Biztosítási és pénzügyi matematika mesterszak

A lista még nem végleges, reméljük rövidesen új témákkal bővül

1. Szabadon választható téma.
Témavezető: A tanszék bármelyik oktatója.
A téma rövid leírása: Ha egy hallgató tetszőleges pénzügyi matematikai vagy biztosítási matematikai téma iránt érdeklődik, akkor témavezetőnek választhatja azt a szakembert, aki ehhez ért, és ebben segítséget tud neki nyújtani.
Ajánlott irodalom: a hallgató és a témavezető megállapodása alapján.
Ajánlott szakirányok: mindegyik.

2. A rendszerkockázat különböző sztochasztikus modelljei (foglalt)
Témavezető: Backhausz Ágnes (agnes"at"cs.elte.hu).
A téma rövid leírása: Az utóbbi években a figyelem előterébe került a banki rendszerkockázat modellezése, vagyis annak megértése, hogy egy piaci szereplőnél bekövetkező történések (pl. nagyobb veszteség, esetleg csőd) hogyan hatnak a többi szereplőre és a rendszer egészére. A rendszerkockázat mérésére, illetve a bekövetkező hatások terjedésének vizsgálatára különböző matematikai modellek születtek. Vannak sztochasztikus differenciálegyenleteket használó, véletlen pontfolyamatokat (például Hawkes-folyamatokat), illetve véletlen gráfokat alkalmazó megközelítések is. A feladat a szakirodalom alapján a különféle matematikai módszerek összehasonlítása, az előnyök és hátrányok bemutatásával, illetve valamelyik megközelítéshez saját számítógépes szimuláció készítése.
Ajánlott irodalom:
[1] E. Errais, K. Giesecke and L. R. Goldberg: Affine point processes and portfolio credit risk. SIAM Journal on Financial Mathematics 1 (2010), no. 1., 642--665.
[2] A. Lesniewski, A. Richter: Managing counterparty credit risk via BSDEs. arXiv:1608.03237 [q-fin.RM]
Ajánlott szakirányok: mindkét szakirány.

3. Hogyan árazzunk be egy stop loss viszontbiztosítást?
Témavezető: Berki László (berki.laszlo"at"nn.hu, berkilacas"at"gmail.com)
A téma rövid leírása: A biztosítók egyik legfontosabb kockázatporlasztási eszköze a viszontbiztosítás. Az elmúlt években azonban a Szolvencia II-es szabályozás miatt a tőkeoptimalizálási szerepe is jelentősen megnőtt, így kulcsfontosságúvá vált az egyes viszontbiztosítási formák közötti eltérések mélyebb szintű feltérképezése. A szakdolgozatban be kell mutatni, hogy a stop loss típusú viszontbiztosításnak milyen előnyei / hátrányai vannak a többi (életbiztosításban használatos) ismert formával szemben, ill. hogyan hat összességében a vállalat mérlegére. Mennyire drága a stop loss, és ha az, megéri-e?
Ajánlott irodalom:
[1] Mette M. Rytgaard: *Stop Loss Reinsurance* (2004);
[2] Rajko Reijnen, Willem Albers, Wilbert C.M. Kallenberg: *Approximations for stop-loss reinsurance premiums* (2005);
[3] Jun Cai, Ken Seng Tan: *Optimal retention for a stop-loss reinsurance under the VaR and CTE risk measures* (2007)
Ajánlott szakirány: aktuárius

4. Pricing methods in FX markets (foglalt)

Témavezető: Molnár-Sáska Gábor (Gabor.Molnar-Saska”at”morganstanley.com)

Ajánlott szakirány: kvantitatív pénzügy.

5. Atlasz modell

Témavezető: Prokaj Vilmos (prokaj”at”cs.elte.hu)

A téma rövid leírása:

A szakdolgozat célja a vonatkozó irodalom áttekintése.

Ajánlott irodalom:

[1] Ichiba T, Papathanakos V, Banner A, Karatzas I and Fernholz R (2011), "Hybrid Atlas models", Ann. Appl. Probab.. Vol. 21(2), pp. 609-644.

[2] Banner AD, Fernholz R and Karatzas I (2005), "Atlas models of equity markets", Ann. Appl. Probab.. Vol. 15(4), pp. 2296-2330.

[3] Fernholz R (2001), "Equity portfolios generated by functions of ranked market weights", Finance Stoch.. Vol. 5(4), pp. 469-486.

Ajánlott szakirány: kvantitatív pénzügy.

6. Érzékenység számítás Malliavin kalkulussal

Témavezető: Prokaj Vilmos (prokaj”at”cs.elte.hu)

A téma rövid leírása:

Egy származtatott termék árának függése a különböző model paraméterektől fontos mennyiség a pénzügyi matematikában. Ezeknek az érzékenységeknek a számítása a legegyszerűbb modellektől eltekintve Monte-Carlo módszerekkel történik. A naív numerikus deriválás helyett bizonyos modellekben lehet ügyesebben is számolni. A szakdolgozat célja a vonatkozó irodalom áttekintése. Lehetőség van a megismert módszerek implementálására, hatékonyságuk numerikus vizsgálatára.

Ajánlott irodalom:

[1] Fourni\'e, E., Lasry, J.-M., Lebuchoux, J., and Lions, P.-L. (2001). Applications of Malliavin calculus to Monte-Carlo methods in finance. II. Finance Stoch., 5(2):201–236.

[2] Fourni\'e, E., Lasry, J.-M., Lebuchoux, J., Lions, P.-L., and Touzi, N. (1999). Applications of Malliavin calculus to Monte Carlo methods in finance. Finance Stoch., 3(4):391–412.

Ajánlott szakirány: kvantitatív pénzügy.

7. Benfentes információ modellezése filtráció bővítéssel

Témavezető: Prokaj Vilmos (prokaj”at”cs.elte.hu)

A téma rövid leírása:

Matematikailag a benfentes információt, azaz az árfolyam alakulására vonatkozó plusz információt, filtráció bővítéssel lehet modellezni. A filtráció bővítésével az árfolyamat szemimartingál felbontása megváltozhat. Ennek eredményeként benfentes kereskedő által elérhető utility magasabb lehet, mint a közönséges befektető által elérhető. Bizonyos esetben, de nem mindig, arbitrázs lehetőség is kialakulhat. A szakdolgozat célja a vonatkozó irodalom áttekintése, az árfolyamat felbontásának kiszámítása egyszerű modellekben, ill. bizonyos típusú bővítések esetében.

Ajánlott irodalom:

[1] Amendinger, J., Imkeller, P., and Schweizer, M. (1998). Additional logarithmic utility of an insider. Stochastic Process. Appl., 75(2):263–286.

[2] Imkeller, P., Pontier, M., and Weisz, F. (2001). Free lunch and arbitrage possibilities in a financial market model with an insider. Stochastic Process. Appl., 92(1):103–130.

[3] Imkeller, P. (2003). Malliavin's calculus in insider models: additional utility and free lunches. Math. Finance, 13(1):153–169. Conference on Applications of Malliavin Calculus in Finance (Rocquencourt, 2001).

Ajánlott szakirány: kvantitatív pénzügy.

SolvencyAnalytics témái

8. **Thesis topic: Fixed Income Portfolio Optimization under different risk measures (#REF-op1)**

Belső konzulens: Michaletzky György

Information about the Company

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Introduction

The standard approach in portfolio optimization on the equity market is the mean-variance optimization theory which was introduced by Markowitz. This theory was directly applicable to the equity market, and became a standard in that area.
However, the majority of the world's investments are held in fixed income securities, where the application of this model is not as straightforward as for equities. Therefore a model extension for fixed income securities has been proposed in the literature by including interest rate term structure models into the mean-variance framework.
The changes in the last decades in the interest rate levels and volatilities, and pressure from financial regulators are further increasing attention to fixed income portfolio optimization methodologies. As the risk estimation by variance was replaced by other risk measures (VaR, ES, etc.) in the market, the classic mean-variance optimization techniques became outdated.

In the context of Solvency II and the Swiss Solvency Test, VaR and ES are the respective measures assessing quantitative risk. Portfolios that are optimized according to the above risk measures are likely to be treated more favorably under the respective regulations. From a portfolio management point of view, note that most portfolios have investment constraints on ratings, sectors, currency, and other characteristics. Including such constraints into the optimization problem is therefore essential.

Goals of the Thesis

- Formulate the portfolio optimization problem with interest rate term structure models (e.g. Vasicek, HW, HJM)
- Apply different types of risk measures in the optimization
- Analyze the differences and connections between these models and model selection effects on the optimal portfolio
- Perform an empirical study on a bond market
- Implement term structure models and fixed income optimizer in Python or Matlab

- Implement and analyze different bond market constraints (linear constraints on duration, sectors, currencies, regions, etc.)
- If possible, assess the impact of the resulting portfolios under Solvency II (i.e. Solvency Capital Requirement)

References

- Frank J. Fabozzi, Steven V. Mann (2005): Handbook of Fixed Income Securities, McGraw-Hill
- O Korn, C Koziol (2006): Bond Portfolio Optimization: A Risk-Return Approach, The Journal of Fixed Income
- R. Tyrrell Rockafellar, Stanislav Uryasev (2000): Optimization of conditional value-at-risk, Journal of risk
- Yasuhiro Yamai, Toshinao Yoshiba (2002): Comparative Analyses of Expected Shortfall and Value-at-Risk: Their Estimation Error, Decomposition, and Optimization, Monetary and economic studies
- Jessica James, Nick Webber (2000): Interest Rate Modelling, John Wiley and Sons
- Mark Fisher, Douglas Nychka, David Zervos (1994): Fitting the term structure of interest rates with smoothing splines, FEDS 95-1
- Jerry Yi Xiao (2001): Term Structure Estimations for U.S. Corporate Bond Yields. RiskMetrics Journal 2(1)
- Brigo/Mercurio: Interest Rate Models - Theory and Practice. Springer Finance, 2006

Award

Your thesis is eligible for an award if following points are covered:

- Literature review
- Python, iPython notebook, or Matlab implementation
- Use broad dataset for model validation

Ajánlott szakirány: kvantitatív pénzügy.

9. **<u>Thesis topic: VaR and ES Optimization of multi-asset-class ETF portfolios under regulatory constraints (#REF-op2)</u>**

<u>Belső konzulens:</u> Michaletzky György
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Introduction

As the regulatory pressure grows, models which are able to consider the new definitions of risk, and procedures which can handle the related constraints and limits became increasingly important to financial market participants.
To handle portfolio construction problems, the Markowitz type mean-variance optimization method is one of the key analytical tools worldwide. However, by the evolution of risk measures the classic theory became outdated and the extension of the

model became inevitable. Today the two most important risk measures accepted and applied by regulations are Value at Risk and Expected Shortfall.

The aim of this thesis topic is to include the above mentioned risk measures in portfolios of Exchange Traded Funds (ETFs). ETFs have been increasingly popular investment vehicles in the last 20 years, mainly due to their broad diversification, low costs and simple tradability. A portfolio of ETFs benefits from these funds' favourable characteristics while diversifying into different asset classes.

For Solvency II regulated investors a portfolio that is optimized towards VaR or ES is likely to be attractive. Consider investment constraints e.g. on asset classes in the optimization framework and if possible, include Solvency II related aspects such as the various market Solvency Capital Requirements and the equity symmetric adjustment.

Goals of the Thesis

- Formulate the portfolio optimization problem with different risk measures, wherever needed introduce approximation methodologies
- Analyze the set of efficient portfolios under different assumptions on return distribution
- Analyze changes in the efficient frontiers invoked by the different model variations
- Perform an empirical study on ETF markets
- Analyze the differences and connections between these models and model selection effects on the optimal portfolio results
- Implement optimizer in Python or Matlab
- Introduce Solvency II related aspects (e.g. Solvency Capital Requirement and symmetric adjustment)

References

- R. Tyrrell Rockafellar, Stanislav Uryasev (2000): Optimization of conditional value-at-risk, Journal of risk
- Yasuhiro Yamai, Toshinao Yoshiba (2002): Comparative Analyses of Expected Shortfall and Value-at-Risk: Their Estimation Error, Decomposition, and Optimization, Monetary and economic studies
- Pavlo Krokhmal, Jonas Palmquist, Stanislav Uryasev (2001): Portfolio optimization with conditional value-at-risk objective and constraints, Journal of risk
- Dimitris Bertsimasa, Geo-rey J. Laupreteb, Alexander Samarovc (2004): Shortfall as a risk measure: properties, optimization and applications, Journal of Economic Dynamics and Control

Award

Your thesis is eligible for an award if following points are covered:

- Literature review
- Python, iPython notebook, or Matlab implementation
- Use broad dataset for model validation

Ajánlott szakirány: kvantitatív pénzügy.

10. Thesis topic: Convertible Bond Pricing under Solvency II (#REF-cb3)

Belső konzulens: **Prokaj Vilmos**

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Introduction

Convertible bonds are corporate bonds with an embedded option to convert into a predefined number of company shares. Consequently, the convertible bond is priced similarly as a corporate bond if the equity price is low (i.e. significantly below conversion price). However, if equity price is significantly above conversion price the convertible bond is likely to be converted and its price behaviour is similar to the underlying shares.

The application of convertible bond pricing models to Solvency II is at the core of this thesis.

Relevancy for Solvency II

Convertible bonds are a hybrid asset class between corporate bonds and equities. They are characterized by a so-called convex payoff profile: a convertible bond's price reacts more to positive equity shocks than to negative shocks of equal absolute size.
As Solvency II uses Value-at-Risk as risk measure instead of volatility, financial instruments with convex payoffs are likely to benefit under this regulatory regime. In order to demonstrate the impact of this complex asset class on an insurance company's solvency capital requirement, the applied asset pricing model has to be able to incorporate specific risk factors. These are the shocks defined in the market risk module of Solvency II.
Note that asset pricing models that tend to produce 'conservative' results may be favoured from regulatory perspective.

Goals of the Thesis

- Literature review of different convertible bond pricing models
- Review of main Solvency II market risk factors
- Implementation of convertible bond pricing functions in Python
- What results do pricing models produce under Solvency II shocks?

- Compare these with empirical data - and if possible, adjust models to produce conservative results (rather underpricing than overpricing under negative shocks)

Basic References

- Balázs Mezőfi: Convertible Bond Pricing - An Empirical Study for Solvency II, Master Thesis, Corvinus University / ELTE, 2015
- Jan De Spiegeleer, Wim Schoutens and Philippe Jabre: The Handbook of Convertible Bonds: Pricing, Strategies and Risk Management. Wiley 2011
- Daniel Niedermayer: Convertible Bonds - Fundamentals, Asset Allocation, Solvency. Credit Suisse 2014 https://www.credit-suisse.com/asset_management/downloads/marketing/wp_broschuere_convertibles_eng.pdf

Academic References

- Bardhan, I. - Bergier, A. - Derman, E. - Dosembet, C. - Kani, I. (1994): Valuing Convertible Bonds as Derivatives. Technical Report, Goldman Sachs.
- Batten, J. A. - Khaw, K. - Young, M. R. (2014): Convertible Bond Pricing Models. Journal of Economic Surveys, Vol. 28. No. 5, pp. 775-803.
- Chambers, D. R. - Lu, Q. (2007): A Tree Model for Pricing Convertible Bonds with Equity, Interest Rate, and Default Risk. The Journal of Derivatives, Vol. 14, pp. 25-46.
- Tsiveriotis, K. - Fernandes, C. (1998): Valuing Convertible Bonds with Credit Risk. Journal of Fixed Income, Vol. 8. No. 2, pp. 95-102.
- Zabolotnyuk, Y. - Jones, R. - Veld, C. (2010): An Empirical Comparison of Convertible Bond Valuation Models. Financial Management, Vol. 39. No. 2, pp. 675-706.

Award

Your thesis is eligible for an award if following points are covered:

- Literature review on Convertible Bonds and Solvency II
- Python implementation of convertible bond pricing models
- Use broad dataset for model validation
- iPython notebook tests and documentation

Ajánlott szakirány: kvantitatív pénzügy.

11. **Dynamic Collar Strategies under Solvency II (#REF_ds2)**

Belső konzulens: **Márkus László**
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Introduction

Equity charges for insurance companies under Solvency II are not only substantial but also linked to a stochastic variable, the so-called symmetric adjustment (SA). The symmetric adjustment varies between +/-10% around standard equity charges of 39% for type 1 equities and 49% for type 2 equities. The SA may not only lead to massive capital charges of up to 49% or 59% but also introduces a source of uncertainty into the financial system as future capital charges become stochastic.

Our intuition tells that in times where equity charges are high due to a positive SA, equity exposure should be lower than in times of negative SA. The aim of this thesis topic is to find trading strategies that exploit this property by achieving long term average returns at lower capital charges.

A way of reducing equity charges is by self financing collar strategies. A 'static' collar strategy would keep the put strike in a constant proportion to the equity's price at each rebalancing date and choose the call's strike price to finance the put option. By this, downside risk and thus, equity capital charge would be reduced at the expense of giving up upside participation.
In contrast to the above, a dynamic collar strategy would choose the put's strike price as a function of the time dependent symmetric adjustment (published monthly on EIOPA's website and which is calculated by comparing current index level with a moving average level of the index). According to our intuition, such dynamic collar strategies should - in the long run - provide lower average equity capital charges while not changing average portfolio performance significantly compared to a static strategy.

The most simple way of backtesting such dynamic collar strategies is using index options on well-known indices. If historical option prices are unknown, you may calculate historical prices with some assumptions on implied volatility and backtest the dynamic collar strategy. The advantage of this method is that for well-known indices, index levels as well as the symmetric adjustments are available (or can be calculated) for over 100 years and that backtests over long periods can be performed.

Note that the results of this thesis have direct practical relevance as the strategy can be easily implemented by some index tracker (ETFs, index funds, index futures etc.) and the corresponding index options.

Goals of the thesis

- Review the Solvency II risk model (pillar 1) with focus on equity charges and symmetric adjustment
- Review and categorize option strategies with focus on self financing collars
- Develop a dynamic collar strategy where the put option's strike is a function of the symmetric adjustment
- Calibrate and backtest this strategy with historical data using a) observed index option prices and b) for long-term studies using calculated option prices
- Apply these strategies to major equity indices (e.g. Eurostoxx, S&P 500, DAX)

Basic References

- Neftci: Principles of Financial Engineering, 2. Edition, Academic Press, 2008 – Chapter 7f
- https://eiopa.europa.eu/

- https://eiopa.europa.eu/regulation-supervision/insurance/solvency-ii
- http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2015:012:FULL&from=EN
- https://eiopa.europa.eu/regulation-supervision/insurance/solvency-ii-technical-information/symmetric-adjustment-of-the-equity-capital-charge

Academic References

- Ahn, D.-H., Boudoukh, J., Richardson, M. and Whitelaw, R. F. (1999), Optimal Risk Management Using Options. The Journal of Finance, 54: 359–375
- Brown, D.-B., Smith J.E.(2011): Dynamic Portfolio Optimization with Transaction Costs: Heuristics and Dual Bounds. Management Science, Vol 57, No. 10: 1752-1770
- Shreve, S. E., H. M. Soner. 1994. Optimal investment and consumption with transaction costs. Ann. Appl. Probab. 4 (3) 609–692.
- Szado, Kazemi (2008): Collaring the Cube: Protection Options for a QQQ ETF Portfolio. Technical Document. http://www.indexcollar.com/wp-content/uploads/2012/11/2-A-umass_collaring_cube.pdf
- Yim, Lee, Yoo, Kim (2011): A Zero-Cost Collar Option Applied to Materials Procurement Contracts to Reduce Price Fluctuation Risks in Construction. World Academy of Science, Engineering and Technology, http://waset.org/Publication/a-zero-cost-collar-option-applied-to-materials-procurement-contracts-to-reduce-price-fluctuation-risks-in-construction/2482

Award

Your thesis is eligible for an award if following points are covered:

- Literature review on equity option strategies
- Python or Matlab implementation of dynamic portfolio strategy
- Empirical validation of results

Ajánlott szakirány: kvantitatív pénzügy.

12. Thesis topic: Solvency II Market Risk: Does the Calibration of the Standard Formula still hold? (#REF-sf1)

Belső konzulens: Zempléni András
Information about the Company

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Introduction

Solvency II requires assets' and liabilities' valuation under market scenarios defined in the market risk module. By applying these scenarios on an insurance company's balance sheet, the solvency capital requirement (SCR) and eventually, an insurer’s solvency coverage ratio can be calculated. With over 4’000 companies with over 7tr EUR assets the regulatory model’s calibration has a key practical relevance.

Clearly, the market risk scenarios defined in the *Commission Delegated Regulation (EU) 2015/35* describe some average figures and are calibrated on some underlying data sample. Some information on the calibration is given in the paper “*The underlying assumptions in the standard formula for the Solvency Capital Requirement calculation (July 2014)*” published by EIOPA. As an example, the interest rate risk calibration has been conducted as follows (see page 14f): “The calibration of the interest rate shocks in the standard formula are based on the relative changes of the term structure of interest rates using the following 4 datasets: EUR government zero coupon term structures (1997 to 2009), GBP government zero coupon term structures (1979 to 2009), and both Euro and GBP LIBOR/swap rates (1997 to 2009). For each of the four individual datasets, stress factors were assessed through a Principal Component Analysis (PCA), according to their maturity.“

Details of this statistics as well as further analyses would be highly relevant. These include:

- statistics of the shocks (i.e on the dispersion)
- sensitivity to the choice of the estimation time window
- how would shocks look like if they were calibrated at different years as well as with current data

Moreover, using a sample insurance’s balance sheet data provided by SolvencyAnalytics, show the impact of the different calibrations on this company’s solvency coverage ratio.

Goals of the Thesis

- Review on Solvency II market risk framework
- Review of statistical models used for Solvency II calibration and of alternative models
- Implement the basic Solvency II framework in Python (some help may be provided by SolvencyAnalytics)
- Show the sensitivity of the Solvency II shock calibration to underlying data
- Show the sensitivity of a sample insurance company’s solvency coverage ratio to the choice of the underlying data

Basic References

- EIOPA: *Commission Delegated Regulation (EU) 2015/35* (esp. pages 104f) http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2015:012:FULL&from=EN
- EIOPA: *The underlying assumptions in the standard formula for the Solvency Capital Requirement calculation (July 2014)* https://eiopa.europa.eu/Publications/Standards/EIOPA-14-322_Underlying_Assumptions.pdf
- https://eiopa.europa.eu/CEIOPS-Archive/Documents/Advices/CEIOPS-L2-Advice-Market-risk-calibration.pdf

- https://eiopa.europa.eu/CEIOPS-Archive/Documents/Advices/CEIOPS-Calibration-paper-Solvency-II.pdf
- http://www.cequra.uni-muenchen.de/download/cequra_wp_041.pdf
- http://arxiv.org/pdf/1506.04125v1.pdf

Award

Your thesis is eligible for an award if following points are covered:

- Literature on Solvency II and related statistical estimation methods
- Python implementation of the models and estimations
- Use long dataset

Ajánlott szakirány: kvantitatív pénzügy.

A SolvencyAnalytics szakdolgozati témáiról részletes információ