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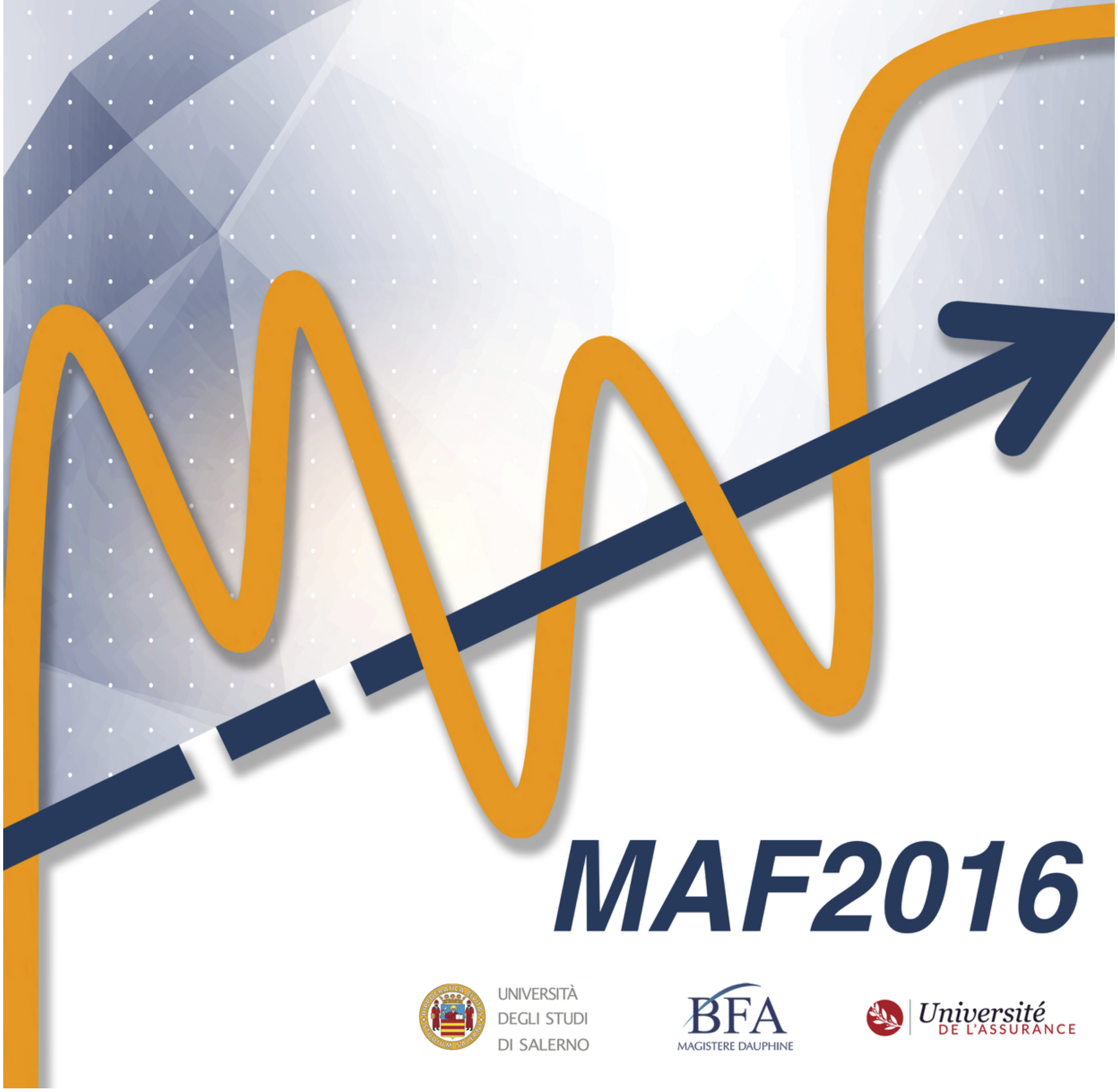

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Preface

We are proud to present the *Book of Abstracts* of the contributions accepted for presentation at the *Colloque MAF - Mathematical and Statistical Methods for Actuarial Sciences and Finance.*

Since 2004, the International MAF Conferences have been held every two years in Salerno (2004, 2006, 2010, 2014) and Venice (2008, 2012). The current edition is held in Paris, from March 30 to April 1, 2016.

The conference has been organized by the MBA Centre des Hautes Etudes d'Assurances of the University Dauphine of Paris (France) and the Department of Economics of the Ca' Foscari University of Venice (Itay), with the collaboration of the Department of Economics and Statistical Sciences of the University of Salerno (Italy).

Its main aim is to promote the collaboration between mathematicians and statisticians, in order to provide new theoretical and methodological results, and significant applications in actuarial sciences and finance, by the capabilities of the interdisciplinary mathematical-and-statistical approach.

The conference covers a wide variety of subjects in actuarial science and financial fields, all treated in light of the interaction between the two quantitative approaches. It is open to both academicians and professionals, to encourage the cooperation between theoreticians and practitioners.

Venice, March 2016

Marco Corazza
Francesca Parpinel
Claudio Pizzi

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Credit rating announcements and bond liquidity*

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J.E.L. classification: G12, G14, C34.

Abstract

Information on rating actions has been a permanent subject of debate. Credit rating agencies (CRAs) state that they consider insider information when assigning and revising ratings, without disclosing specific details to the public at large. The literature examines prices and/or returns responses to rating events. However, the information about the creditworthiness of issuers disclosed by rating actions can not only affect prices. Besides this, it can induce specific market dynamics concerning the liquidity of the re-rated bonds. One important role of ratings is to reduce the information asymmetry between lenders and borrowers. As this asymmetry is inversely related to liquidity, if credit rating changes (CRCs) release specific news about the financial situation of firms, they will affect firms bond liquidity. In addition, other factors, such as the regulatory constraints affecting investors in bond markets, could cause a response of liquidity after CRCs, independently of their informational content.

In order to analyze this question, we go beyond the traditional price analysis by analyzing corporate bond liquidity patterns around CRC announcements, and their interactions with prices and yield spreads. We examine different dimensions of corporate bond liquidity, including trading activity, the price impact of trades, and market share measures. We compute different adaptations to bond markets of traditional microstructure-based liquid measures on stock markets: the Amivest liquidity ratio ([1]), the Imputed Roundtrip Cost (IRC) proposed by [3] and the [2] measure, based on the serial price covariance, and the price dispersion. We also include two proxies of the trading volume, i.e. the raw trading volume and the market share, and one proxy of the trading frequency, i.e. the number of trades. Recent papers using some of these measures corroborate the liquidity effects on prices (see, e.g., [2]; [3]; [4]).

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We study a comprehensive sample of 2,727 CRCs in the whole US corporate bond market, using TRACE transaction data from 2002 to 2010. We also study the impact of the recent global financial crisis on the response of the different liquidity aspects to CRC announcements. We consider the default of Lehman Brothers in mid-2008 to be the starting point of the financial turmoil.

This paper investigates liquidity shocks on the US corporate bond market around CRC announcements. These shocks are induced by the information content of the announcement itself and by regulatory constraints. Abnormal trading activity can be triggered by the release of information after any upgrade or downgrade; however, even if the event conveys no new information to the market, changes on liquidity can be originated if the credit note change affects bond holding restrictions. We show that: (1) the market anticipates rating changes, since trends in prices, yield spreads and liquidity proxies prelude the event, and additionally, large volume transactions are detected the day before the downgrade; (2) the concrete materialization of the announcement is not fully anticipated, since we only observe price overreaction immediately after downgrades; (3) trading activity collapses the day before a fallen angel downgrade, and price and transaction size remain stable after the announcement; (4) no evidence of massive fire sales is obtained; (5) rising star upgrades improve the trading activity; (6) a clear asymmetric reaction to positive and negative rating events is observed; (7) different agency-specific and rating-specific features are able to explain liquidity behavior around rating events; (8) financial distress periods exacerbate liquidity responses derived from downgrades and upgrades.

References

1. Amihud, Y., Mendelson, H., Lauterbach, B.: Market microstructure and securities values: evidence from the Tel Aviv Exchange. *Journal of Financial Economics,* **45(2)** (1997) 365-390.
2. Bao, J., Pan, J., Wang, J.: The illiquidity of corporate bonds. *The Journal of Finance,* **66(3)** (2011) 911-946.
3. Dick-Nielsen, J., Feldhtter, P. Lando, D.: Corporate bond liquidity before and after the onset of the subprime crisis. *Journal of Financial Economics,* **103(3)** (2012) 471-492.
4. Friewald, N., Jankowitsch, R. Subrahmanyam, M.: Illiquidity or credit deterioration: A study of liquidity in the US corporate bond market during financial crises. *Journal of Financial Economics,* **105** (2012), 18-36.

Optimal asset allocation strategies in funded pension schemes

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J.E.L. classification: C58, G11, G17, G19.

Abstract

In this paper, we consider a funded pension scheme and we examine the optimal asset liability management strategies that the manager of the scheme should follow in order to be able to cover the liabilities. We consider the situation of some of the most commonly used portfolio asset allocation methods which involve long term investment decisions that will enable the pension scheme to meet the pension liabilities guaranteed. This study presents a plethora of advanced multivariate econometric models which forecast the mean and variance-covariance of the asset returns in order to create optimal asset allocation models.

Previous studies on pension funds only focuses on a specific econometric model such as using Vector Autoregression (VAR) to model its asset return covariances, without comparing the different models ([4], [5], [6]). However, there are many other multivariate econometric models which can capture different characteristics of the data. The contribution of this study is that we design a comparative study which considers both the asset and liabilities modeling in pension funds. We consider different models for the asset allocation process of the pension fund and also for risk management purposes to see which of the model is the best in optimizing the portfolio return in a pension fund.

In particular, we consider a wide variety of stock and bond indices in which pension funds can invest on in UK, US and Europe. The data cover monthly price indices from 1985 to 2015. There is evidence for the presence of heteroskedasticity, fat tails and volatility clustering in the asset returns of the data. These have important implications in assessing whether the chosen risk model is appropriate. We use multivariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models since these models are designed to deal with these 'stylized facts'. Also, we use Copula models to analyze numerous dependence structures and to discover possible asymmetries in the data. We apply different model specifications of forecasting mean and variance-covariances matrix : (i) Constant Conditional Correlation (CCC) model [1], (ii) Vector autoregressive moving-average (VARMA)-GARCH model (iii) Dynamic Condition Correlation (DCC) [3], (iv) VAR DCC GARCH and (v) GARCH-Copula. Specifically, this study use symmetric GARCH model and an asymmetric version of it (GJR-GARCH) such

that the models are implemented with the multivariate Normal and Student distributions, with dynamic and static estimation of the correlation. By employing different model specifications, we are able to explore the empirical applicability of the multivariate GARCH model when estimating large conditional covariance matrices.

We solve a mean-variance portfolio selection problem following [2], [5], [7], with aims to look at the performance of portfolios and constructing optimal portfolios which maximize the investor's return for the minimum level of risk. The mean-variance optimization model quantifies the risk by using the variance, which enables fund managers to seeking the lowest variance for a given expected return after specifying their acceptable risk level. Finally, we compare the models based on the risk-adjusted performance measure such as Sharpe ratio, Sortino ratio and other risk measures. We evaluate the forecasts performance by using number of different portfolio optimization strategies.

References

1. Bollerslev, T., Engle R.F., Wooldridge J.M.: A Capital Asset Pricing Model with Time Varying Covariances. *Journal of Political Economy* **96** (1998) 116-131.
2. Basak, S., Chabakauri, G.: Dynamic mean-variance asset allocation. *Review of Financial Studies* **23** (2010) 2970-3016.
3. Engle, R.: Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models. *Journal of Business & Economic Statistics* **20** (2002) 339-350.
4. Ferstl R., Weissensteiner A.: Asset-Liability Management under Time-Varying Investment Opportunities. *Journal of Banking & Finance* **35** (2011) 182-192.
5. Hoevenaars R.P.M.M., Molenaar R.D.J., Schotman P.C., Steenkamp T.B.M.: Strategic asset allocation with liabilities: Beyond stocks and bonds. *Journal of Economic Dynamics & Control* **32** (2013) 2939-2970.
6. Koivu M., Pennanen T., Ranne A.: Modeling assets and liabilities of a finnish pension insurance company: a VEqC approach. *Scandinavian Actuarial Journal* **1** (2005) 46-76.
7. Vigna, E.: On efficiency of meanvariance based portfolio selection in defined contribution pension schemes. *Quantitative Finance* **14** (2014) 237-258.
8. Vrontos, S.D., Vrontos, I.D., Meligkotsidou L.: Asset-Liability Management for Pension Funds in a Time-Varying Volatility Environment. *Journal of Asset Management* **14** (2013) 306-333.

Optimal mix between pay-as-you-go and funding in a multi-generational overlapping generations model

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J.E.L. classification: G11, H55, H75, J32

Abstract

Public pension systems are usually pay-as-you-go (PAYG) financed, that is, current contributions cover the pension expenditures. However, its rate of return tends to be lower than the rate of return on funding, especially in countries where the working population is staggering. Therefore, funded systems seem to be preferred when solely the mean return is taken into account. However, the high-variability of the funding rate of return makes the choice between PAYG and funding less obvious and diversification benefits may appear, see [6] and [5].

In this paper we study the optimal allocations or proportions between funding and PAYG in a Markovitz mean-variance framework when M discrete heterogeneous cohorts coexist. In practice, mixing NDC and Financial Defined Contribution (FDC) has already been implemented. Sweden, Latvia and Poland ([4] and [1]) already split individual contributions between funding and pay-as-you-go. Sweden allocates 86,5% of the contributions to PAYG, whereas Latvia and Poland allocate 70% and 62.6% respectively. This implies that 86,5% of the Swedish contributions accrue PAYG pension rights, and earn the notional rate, whereas the remaining part accrues funded pension rights and earns the market rate of return.

The optimal portfolio allocation problem between funded and unfunded cannot be studied as already done for defined contribution pension schemes in the classical literature. The nature of the PAYG asset doesn't allow the government to sell past endowment to purchase more shares in funding if the financial markets perform better and therefore the self-financing hypothesis doesn't hold. Past allocations are held until maturity and the government is only capable of adapting current and future allocations.

The optimal allocations are calculated in two different cases. First, the optimal allocation which maximizes the (ex-ante) expected utility of the relative wealth for an entering cohort is obtained. This is a generalization of the work of [3] and [2]. However, it may not be possible to provide optimality for the cohorts and liquidity simultaneously when population is non-stationary and returns are stochastic. Therefore, at a second stage the ex-post expected utility of the relative wealth is calculated according to the filtration at time of calculation and no longer according to the filtration at start of the career (ex-ante). Furthermore, a liquidity constraint is added to adapt the optimal proportions depending on the liquidity of the system. Liquidity refers to PAYG contributions being sufficient to cover the PAYG pension expenditures.

We find that there are clear diversification benefits in most of the cases analysed. For instance, for the ex-ante case we find that diversification occurs for any risk aversion coefficient if the economy is dynamically efficient. However, the analysis suggests also that there are no diversification benefits in the ex-post case when the correlation between the financial and demographic asset is positive.

References

1. Chłón-Domińczak, A., Franco, D., Palmer, E.: Parallel Lines: The First Wave of NDC Reforms: The Experiences of Italy, Latvia, Poland, and Sweden. In: Holzmann, R., Palmer, E. and Robalino D. (eds.): *Nonfinancial Defined Contribution Pension Schemes in a Changing Pension World*, Vol. 1 Progress, Lessons, and Implementation. The World Bank (2012) 31–85.
2. Devolder, P., Melis, R.: Optimal mix between pay as you go and funding for pension liabilities in a stochastic framework. *ASTIN Bulletin* **45** (2015) 551–575.
3. Dutta, J., Kapur, S., Orszag, J. M. : A portfolio approach to the optimal funding of pensions. *Economics Letters* **69** (2000) 201–206.
4. Könberg, B., Palmer, E., Sunden, A.: The NDC reform in Sweden: the 1994 legislation to the present. In: Holzmann, R. and Palmer, E. (eds.): *Pension Reform: Issues and Prospects for Non-Financial Defined Contribution (NDC) Schemes*. The World Bank (2006) 449–467
5. De Menil, G., Murtin, F., Sheshinski, E.: Planning for the optimal mix of paygo tax and funded savings. *Journal of Pension Economics and Finance* **5** (2006) 1–25.
6. Persson, M.: The NDC reform in Sweden: Five fallacies in the social security debate. In: Ihori, Toshihiro and Tachibanaki, Toshiaki (eds.): *Social Security Reform in Advanced Countries: Evaluating Pension Finance*. Routledge Press, London (2002) 39–51

Economic and demographic risks for Pay-as-you-go pension schemes: Defined Benefit versus Defined Contribution

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J.E.L. classification: H55, H75, J32

Abstract

Public pension systems are usually financed on a pay-as-you-go (PAYG) basis where pensions for retirees are paid by the contributions of the working-age population. As a result of the decrease in birth rates and increase in life expectancy, a common trend in some European countries has been a wave of parametric or even structural reforms, by changing the formula to calculate the initial pension from a Defined Benefit (DB) to a Defined Contribution (DC), with the aim of reducing the expenditure on pensions [8].

DC unfunded pension schemes (also called Notional Defined Contribution accounts) has some positive features, such as facing the population ageing more or less automatically or improving the relationship between contributions and pension paid [4]. However these schemes do not guarantee sustainability, due to the PAYG nature ([7] and [5]), or secure an adequate level of benefits at all times.

In this line, [2], [3] and [1] study numerically the fiscal sustainability of NDCs, their performance in regards of risk-spreading among generations and how economic and demographic shocks are spread among different generations. However, their numerical approach doesn't study jointly the pension adequacy, the actuarial fairness and the sustainability of the system.

For policymakers, a desirable pension system consists of an adequate income for pensioners in the retirement phase, a fair level of benefits in relation to the

contributions paid (actuarial fairness) [6] and at the same time a sustainable pension system in the long run.

This paper analyses, from a theoretical point of view, how different pension designs, such as DB (including points system), DC or hybrid, react to economic and demographic risks in terms of pension adequacy, fairness and sustainability. Also, we aim to propose a pension design that better reacts to the adverse and uncertain challenges that negatively affect pension systems.

This research will certainly contribute to the debate on pension finance.

References

1. Auerbach, A.J., Kueng, L., Lee, R.: Propagation and Smoothing of Shocks in Alternative Social Security Systems. *National Bureau of Economic Research - Working papers* **19137** (2013).
2. Auerbach, A.J., Lee, R.: Notional defined contribution pension systems in a stochastic context: design and stability. In: Brown, J.R., Liebman, J.B., Wise, D.A. (eds.): *Social Security Policy in a Changing Environment.* University of Chicago Press (2006).
3. Auerbach, A.J., Lee, R.: Welfare and generational equity in sustainable unfunded pension systems. *Journal of public economics* **95** (2011) 16–27.
4. Palmer, E.: What's NDC?. In: Holzmann, R., Palmer, E. (eds.): *Pension Reform: Issues and Prospects for Non-Financial Defined Contribution (NDC) Schemes.* The World Bank (2006) 318–362.
5. Palmer, E.: Generic NDC: Equilibrium, Valuation, and Risk Sharing with and without NDC Bonds. In: Holzmann, R., Palmer, E., Robalino D. (eds.): *Nonfinancial Defined Contribution Pension Schemes in a Changing Pension World*, Vol. 2. Gender, Politics, and Financial Stability. The World Bank (2012) 309–343.
6. Queisser, M., Whitehouse, E.R.: Neutral or fair?: actuarial concepts and pension-system design. *OECD Social, Employment and Migration Working Papers* **40** (2006).
7. Valdés-Prieto, S.: The Financial Stability of Notional Account Pensions. *Scandinavian Journal of Economics* **3** (2000) 395–417.
8. Whitehouse, E.R.: Parallel Lines: NDC Pensions and the Direction of Pension Reform in Developed Countries. In: Holzmann, R., Palmer, E., Robalino D. (eds.): *Nonfinancial Defined Contribution Pension Schemes in a Changing Pension World*, Vol. 1 Progress, Lessons, and Implementation. The World Bank (2012) 85–106.

Some guiding principles for the development of self-adjusting mechanisms for sustainable retirement systems

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J.E.L. classification: G22, J26.

Abstract

Most of the developed countries are experiencing fertility rates below population replacement levels and increasing life expectancy. These demographic factors are exerting a financial strain on the delivery of social security retirement benefits. In response to these and other pressures, some countries have adopted mechanisms that are designed to make the system self-adjust financially, so that it is sustainable. A sustainable system is one that delivers on its financial commitments in such a way that the financial burden is borne equitably by participants over the long term. The paper begins with an overview of the literature on automatic balancing mechanisms, in both defined benefit and notional defined contribution systems. It reviews the self-adjustment mechanisms of Canada, Germany, Japan and Sweden, and derives five guiding principles for the development of self-adjustment mechanisms for sustainable social security retirement systems. The list is not presented as complete, but is a starting point for those designing or adopting adjustment mechanisms and for researchers.

References

1. lho, J.M., Lassila J., Valkonen, T.: Demographic Uncertainty and Evaluation of Sustainaility of Pension Systems. *Pension Reform: Issues and Prospects for Non-Financial Defined Contribution (NDC) Schemes.* R. Holzmann and E. Palmer, Eds. The World Bank, Washington, D.C., (2006) 95-112.
2. Boada-Penas, Maria del Carmen, Carlos Vidal-Melia and Junichi Sakamoto. Models of the Actuarial Balance of the Pay-As-You-Go Pension System. A Review and Some Policy Recommendations. (2010).
3. Borsch-Supan, A., A. Reil-Held and C.B. Wilke. *How to make a Defined Benefit System Sustainable: The Sustainability Factor in the German Benefit Indexation Formula.* Discussion Paper No. 37, Mannheim Institute for the Economics of Aging, Mannheim University, (2003) 1-34.
4. Cichon, M. Balanced Notional Defined Contribution Schemes: A new geist in old bottles? *Scandinavian Insurance Quarterly 2005*, (2005) 174-190.

5. Letzner, P. and O. Tippelmann. A German perspective of the new Swedish public pension system. *Scandinavian Insurance Quarterly*, (2004) 315-325.
6. Menard, J-C., A. Billig, O.B. Sorensen, and F. Leger. *Intergenerational equity: a condition for sustainable social security?* (2013).
7. Monk, A.H.B and S.A. Sass. *Risk Pooling And The Market Crash: Lessons From Canada's Pension Plan.* Center For Retirement Research At Boston College, Boston, MA., 1-11 (2009).
8. Turner, J.A. *Automatic Balancing Mechanisms.* (2009).
9. Whitehouse, E. *Life-Expectancy Risk and Pensions: Who Bears the Burden?* OECD Social Employment and Migration Working Papers No. 60. Paris, France (2007).

Defensive medicine, liability insurance and malpractice litigation in an evolutionary model

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J.E.L. classification: C62, C73, I13.

Abstract

We model the interactions between physicians and patients subject to clinical and legal risks by means of evolutionary game theory. We propose an original game in which patients can resort to litigation, and physicians can prevent negligence charges through defensive medicine or liability insurance. The game works as follows. At each instant of continuous time, there is a large number of random pairwise encounters between the two populations. In each encounter, a physician provides a risky medical treatment to a patient. The treatment can fail because of an adverse event; if that happens, the patient may decide to suit the physician and seek compensation. Physicians may take actions to reduce the risk of being sued: by practicing defensive medicine, which improves their chances of winning a lawsuit, or by buying liability insurance, which protects them from possible charges. Alternatively, a physician can choose to act to the best of ones competence without trying to reduce legal risks.

Hence we study the consequent dynamics, turning out to be represented by a four-dimensional system, whose variables are the ratios of adopted strategies, in both populations, plus the amount itself of the insurance premium. In fact, we prove that, under the assumptions of our model, the introduction of a (private) insurance may play either a stabilizing or a destabilizing role, in that it may also induce a more oscillating behavior in the choices of both populations (as regards, respectively, defending from possible lawsuits and resorting to litigation). Moreover, we show that not only the entity, but the way itself by which the premium is calculated (i.e, the premium calculation principle) can influence the eventual outcome of the game (being it a Nash equilibrium or a recurrent set).

References

1. Antoci, A., Fiori Maccioni, A., Russu, P.: The Ecology of defensive medicine and malpractice litigation. *Uniss Research Working Paper.* (2014).

2. Avraham, R.: Clinical practice guidelines: the warped incentives in the US healthcare system. *American journal of law & medicine* **37(1)** (2011) 7-40.
3. Rodwin, M. A., Chang, H. J., Ozaeta, M. M., Omar, R. J.: Malpractice premiums in Massachusetts, a high-risk state: 1975 to 2005. *Health Affairs* **27(3)** (2008) 835-844.
4. Studdert, D. M., Mello, M. M., Sage, W. M., DesRoches, C. M., Peugh, J., Zapert, K., Brennan, T. A.: Defensive medicine among high-risk specialist physicians in a volatile malpractice environment. *JAMA* **293 (21)** (2005) 2609-2617.
5. Vincent, C., Phillips, A., Young, M.: Why do people sue doctors? A study of patients and relatives taking legal action. *The Lancet* **343 (8913)** (1994) 1609-1613.

Payment systems and cryptocurrency: the role of the Central Bank in its regulation, methods of mutual effect evaluation

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J.E.L. classification: C82, E42, E43.

Abstract

Modern information and communication processing systems operate huge amounts of financial and economic data (hundreds of terabytes to petabytes). Decision-making within such systems is associated with the need of selection, structuring, summarizing and analyzing this information for the purposes of forecasting and further decision-making. More conventionally considered are questions about information costs, adequacy and availability of information (we have in mind the theory of transaction costs, Famas efficient market hypothesis, the theory of asymmetric information). In the context of modern socio-economic systems, information, in majority of cases, is a product that has its own value, not always linked to the issue of costs. Relevant to modern financial markets are issues related to the fact, that the transition from the "information-factor of changes" to the "information- object" was made. Under such conditions, it is appropriate to review the role, place and importance of individual subjects in arising financial and economic relations, as well as the methods used to evaluate certain phenomena.

In particular, in these conditions a complete revision of information value /or cost model is required [1, 2]. In relation to the advent of new electronic payment systems, electronic money and cryptocurrency, the building of adequate models of the information value is especially important [3]. It is known that the issuance of cryptocurrency (eg, BitCoins) directly depends on the computing capacity of the issuer and is estimated by increasing over time computing capabilities. On

the other hand, according to optimal computability theory there is an empirical fact that the development of new effective (even optimal) algorithm has an effect comparable to the new generation of computers appearance. This implies that the information value at cryptocurrency issuance, in the general case, is determined by the algorithm complexity of cryptocurrency issue or Kolmogorov algorithmic measure of information. However, already issued BitCoins according to their conversion/sale/purchase form a new market, so the direct use of an algorithmic measure evaluation of cryptocurrency value and exchange rate fluctuations is irrelevant. To construct the information value model in relation to the construction of cryptocurrency market regulation model, the authors suggest applying the information radius [4], proposed in the report [5]. Based on this value model, authors also developed a model for analyzing the flow of financial information, which solves the problem of data sufficiency for the existence of an algorithm that predicts certain socio-financial system indicators.

Thus, along with traditional forms and methods of regulation, less traditional role of the central bank is being considered, associated with its direct participation in the accumulation, storage and processing of financial data.

In this context, the mutual effect of payment systems, electronic money, cryptocurrency and changes in interest rates is examined (in terms of the central banks interest rate policy implementation). Especially interesting is the issue in relation to the different levels of socio-economic systems, as well as to detection of the need for ”engagement” of the central bank in regulation matters.

The relation (the strength of the relationship) between the existence and development of payment systems and the price changes for financial resources remains open.

References

1. Zadiraka, V.K., Kudin, A.M.: *Cloud computing in cryptography and steganography.* Cybernetics and Systems Analysis, Vol. 49, Issue 4, (2013) 584-588.
2. Zadiraka, V., Kudin, A., Shvidchenko, I., Bredelev B.: *Cryptographic and steganographic protocols for cloud systems. In book: Zadiraka V., Nykolaichuk Y. (eds.): Computer technologies in information security*, Ternopil (2015) 9-41.
3. Zadiraka, V.K., Kudin, A.M., Ljudvychenko, V.O., Oleksjuk, O.C.: *Kompjuterni texnolohiji kryptohrafichnoho zaxystu informaciji na special'nyx cyfrovyx nosijax: Navchalnyj posibnyk.* Pidruchnyky i posibnyky, Kiev-Ternopil (2007).
4. Kudin, A.M.: *Cryptographic transformations of non-shannon sources of information.* Cybernetics and Systems Analysis, Vol. 46, Issue 5, (2010) 813-819.
5. Traub, D., Vasyl'kovskyj, G., Vozh'njakovskyj, H.: *Ynformacyja, neopredelennost', slozhnost'.* Myr Publ, Moscow (1988).

Model-independent price bounds for the Swiss Re mortality bond 2003

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J.E.L. classification: G13, G22, G33.

Abstract

In this paper, we are concerned with the valuation of the the first Catastrophic Mortality Bond that was launched in the market namely the Swiss Re Mortality Bond 2003. This bond encapsulates the behaviour of a well-defined mortality index to generate payoffs for the bondholders. Pricing this bond is an arduous task and no closed form solution exists in the literature. We adapt the payoff of the terminal principal of the bond in terms of the payoff of an Asian put option and present a new approach to derive model-independent bounds exploiting comonotonic theory as illustrated in [1] for the pricing of Asian options. The success of these bounds is based on the availability of compatible European mortality options in the market. We carry out Monte Carlo simulations to estimate the bond price and illustrate the strength of the bounds.

Proposition 1. *The random principal payoff X of the Swiss Re bond can be written as the payoff of an Asian put option, i.e.*

$$X = D\left(q_0 - \sum_{i=1}^{3} 5\left(q_{t_i} - 1.3q_0\right)^+\right)^+ \tag{1}$$

with q_{t_i} being the mortality index in the year t_i, t_i = 2004, 2005 or 2006 for $i = 1, 2, 3$ respectively, q_0 is the base value of the mortality index in the year 2002, $D = \frac{C}{q_0}$ and $C = \$400$ million.

Proof. $X = C\left(1 - \sum_{i=1}^{3} L_i\right)^+$ where

$$L_i = \begin{cases} 0 & \text{if } q_{t_i} \leq 1.3q_0 \\ \frac{\left(q_{t_i} - 1.3q_0\right)}{0.2q_0} & \text{if } 1.3q_0 < q_{t_i} \leq 1.5q_0 \\ 1 & \text{if } q_{t_i} > 1.5q_0 \end{cases} \tag{2}$$

is defined by Swiss Re as the principal loss percentage for the year t_i. □

We invoke Jensen's inequality and comonotonicity theory to obtain bounds for the call counterpart of X and then exploit the put-call parity for Asian options to achieve the bounds for X. We derive one upper bound UB_1 and four lower bounds namely LB_0, LB_1, $LB_t^{(1)}$ and $LB_t^{(2)}$, which are sharper in increasing order in sense of their proximity to the actual value of the terminal payoff of the Swiss Re bond. In addition, we work out a lower bound under the Black-Scholes Model namely $LB_t^{(3)}$. The following table presents a snapshot of the tightness of the bounds around the Monte Carlo estimate (MC) assuming that the mortality evolution process $\{q_t\}_{t \geq 0}$ obeys the Black-Scholes model with $q_0 = 0.008453$, the volatility $s = 0.0388$ and a varying interest rate r.

Table 1. Lower and Upper Bounds for Swiss Re Bond under the Black-Scholes Model

r	$\mathrm{LB}_t^{(1)}$	$\mathrm{LB}_t^{(2)}$	$\mathrm{LB}_t^{(3)}$	UB_1	MC
0.000	0.999995778016	0.999995778140	0.999995778143	0.999995778584	0.999995778345
0.005	0.985101139986	0.985101140474	0.985101140486	0.985101141738	0.985101141627
0.010	0.970419124546	0.970419126377	0.970419126422	0.970419129772	0.970419127632

Further, we depict the price bounds in figure 1 below by varying the base value of the mortality index. There is only one earlier publication by [2] in this direction. However these authors propose gain-loss bonds that suffer from model risk. The fact that our bounds are model-independent is a crucial breakthrough in the pricing of catastrophic mortality bonds.

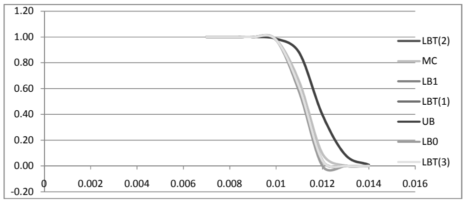

Fig. 1. Price Bounds of the Swiss Re Bond under Black-Scholes Model

References

1. Albrecher, H., Mayer, P. A., Schoutens, W.: General Lower Bounds for Arithmetic Asian Option Prices. *Applied Mathematical Finance* **15(2)** (2008) 123-149.
2. Huang, Y.L. and Tsai, J.T. and Yang, S.S. and Cheng, H.W.: Price Bounds of Mortality-linked Security in Incomplete Insurance Market. *Insurance: Mathematics and Economics* **55** (2014) 30-39.

The cross-border spillover effect of credit rating events on sovereign CDS: evidence on the emerging markets*

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J.E.L. classification: F30, G15, G24, C50.

Abstract

During the last decade, sovereign credit ratings and their impact on sovereign debt have received considerable attention, playing a pivotal role especially for emerging market investments, given the expansion of these economies over recent years. The latest literature confirms that sovereign ratings serve the function of enhancing the transparency of the emerging markets credit risk profile and therefore can significantly influence its national stock and bond market investment flows (see [1]). [3] hypothesize that rating changes within emerging markets have significant information value to improve institutional quality for facilitating long-run financial and economic development. In short, sovereign ratings represent valuations of governments capacity to deal with their financial obligations, as well as their capacity to obtain better financial conditions. Nowadays, emerging sovereigns are among the largest high-yield borrowers in the world; however, their nature is different from other high-yield obligors. Since rating agencies usually assign them the non-investment grade status, they are considered to be more likely to default. However, emerging countries in financial distress generally do not enter bankruptcy proceedings or ever liquidate their assets, but rather they go through debt restructuring mechanisms that allow them to exchange defaulted bonds for new longer maturity, lower yield debt instruments.

This paper extends the literature related to the effect of credit rating announcements on emerging markets, providing new analyses untested to date.

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The vast majority of results in this topic are related to the response of sovereign bond yield spreads to rating credit events produced in the same country. In this sense, we focus the analysis on the cross-border effect using an extensive sample of emerging economies. In particular, the data set consists of the sovereign credit default swaps (CDS) and rating announcements for a total of 45 emerging countries, which we use to construct 7 representative portfolios. Moreover, given the advantages of CDS spreads over bond spreads, we use them as a proxy of the sovereign credit risk, covering a large period from 2004 to 2015. Similar to the related literature, we employ the event study methodology ([2]; [4]) to test the cross-border effects both at the country and the portfolio levels. We distinguish between positive (upgrades) and negative (downgrades) rating events to test the potential asymmetry of events. Additionally, we also examine the effect in different time windows, differentiating between periods surrounding the event (around effect), as well as before and after the event (prior and post effects).

Our empirical findings show that the spillover effect of downgrades occurs more frequently and with a bigger impact, than the effect of upgrades. As we expected, rating announcements are generally related to a competition effect, supporting the results of [4] for international corporate CDS. Sovereign credit risk of non-events countries within the same portfolio benefit (suffer) from downgrades (upgrades), with an improvement (deterioration) in their sovereign CDS levels. However, upgrades display an imitation effect at the portfolio level, where both positive and negative rating announcements positively affect the credit risk of non-event portfolios. Furthermore, the several significant cross-over effects findings support the importance of studying not only the impact of credit rating announcements on the event country, but also on the non-event countries through spillover analysis.

This study may have useful applications. In fact, it allows one to identify the competitive effect produced by credit rating events in emerging cross-border non-event economies. This could help investors to appropriately construct investment portfolios sensitive to sovereign credit risk. In addition, regulators may use these findings when implementing new capital adequacy frameworks for individual countries or portfolios in emerging markets, given the growing importance of the CDS market, which is considered as a good proxy of credit risk.

References

1. Christopher, R., Kim, S. J., Wu, E.: Do sovereign credit ratings influence regional stock and bond market interdependencies in emerging countries?. *Journal of International Financial Markets* **22(4)** (2012) 1070-1089.
2. Finnerty, J. D., Miller, C. D., Chen, R. R.:The impact of credit rating announcements on credit default swap spreads.*Journal of Banking and Finance* **37(6)** (2013) 2011-2030.
3. Kim, S. J., Wu, E.: Sovereign credit ratings, capital flows and financial sector development in emerging markets. *Emerging markets review* **9(1)** (2008) 17-39.
4. Wengner, A., Burghof, H. P., Schneider, J.: The impact of credit rating announcements on corporate CDS markets-Are intra-industry effects observable?. *Journal of Economics and Business* **78** (2015) 79-91.

Quanto implied correlation in a multi-Lévy framework

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J.E.L. classification: G13, G12, C63, D52.

Abstract

The aim of this paper is to explore the problem of recovering market consistent information on the correlation between financial assets using suitable derivatives contracts. Due to the limited number and trading (usually Over-The-Counter - OTC) of products whose price is related to the existing level of correlation, we focus on the case of Quanto products and specifically Quanto futures, as they offer significant exposure to the correlation between exchange rates and asset prices, and are supported by sufficient liquidity.

The interest in market implied metrics of correlation is motivated by the fact that correlation risk is attracting interest for hedging and regulatory purposes. This risk is in fact present in the trading books of a wide range of buy and sell side market participants, such as bank structuring desks and hedge funds for example. Further, the Basel III supervisory regime is focussing in particular on the impact of wrong-way risk effects on the quantification of counterparty credit risk. Capturing correlation risk requires both suitable models for the joint distribution of the relevant variables, and easy-to-implement procedures for the quantification of the parameters of the joint distribution of choice. Specifically, we note that possible information sources are either past observed values of the variables in question, or derivatives whose quoted price offers an estimate of the market perception of correlation. The estimation of historical correlation from time series though is significantly affected by the length of the sample, the frequency of observation and the weights assigned to past observations. Further, as historical measures are backward-looking, they do not necessarily reflect market expectations of future joint movements in the financial quantities of interest, which are instead necessary for the assessment of derivatives positions and related capital requirements. Alternatively, over the past few years the CBOE has

made available daily quotes of the CBOE S&P 500 Implied Correlation Index, which replaces all pairwise correlations with an average one. Although this index in general reflects market capitalization, it might not be suitable for example for pricing and assessing counterparty risk, due to the equi-correlation assumption.

Implied correlation - similarly to implied volatility - shows skew patterns which are not fully consistent with the standard framework based on the Brownian motion, i.e. the Gaussian distribution. A simple but effective way of replacing the Gaussian distribution is the introduction of jumps by adopting Lévy processes. Multivariate constructions for Lévy processes have attracted interest in the literature over the past few years, for example for modelling and pricing in the credit risk and counterparty risk area. Although several approaches are available, in the following we adopt the factor construction of [1], so that the overall risk is decomposed into a systematic part and an idiosyncratic one. The adopted factor construction also implies that the model shows a flexible correlation structure, a linear dimensional complexity, and readily available characteristic functions, which guarantee a high ease of implementation, and allow us to develop an integrated calibration procedure providing access to information on the dependence structure between the relevant components.

In light of the discussion above, this paper offers the following contributions. Firstly, we develop a Lévy processes-based multivariate extended FX framework, which also includes additional names to cater for the underlying assets of Quanto products. En route, we show that the part of the framework concerning the multivariate FX model satisfies symmetries with respect to inversion and triangulation. Secondly, our model gives access to analytical formulae for the correlation coefficient and the indices of tail dependence, which facilitate the recovery of market implied correlation and the assessment of joint movements on the risk position of investors. Thirdly, the proposed model leads to analytical results (up to a Fourier inversion) for the price of both vanilla and Quanto options, which allow for efficient calibration to market quotes. Finally, the application of the proposed model to the pricing of Quanto futures reveals that the quanto adjustment is not only determined by the covariance between asset log-returns (as in the standard Black-Scholes model), but also by higher order cumulants of the jump part of the systematic risk. This implies that market consistent information on the (in general not observable) common component can be extracted directly from the quoted prices, bypassing the need of either imposing unrealistic convolution conditions, or identifying a suitable proxy for this part of the risk. As the same quanto adjustment also enters the pricing formulas of Quanto options, the proposed model allows us to assess the consistency of the information on the existing correlation recovered from Quanto futures and the one extracted from the relevant time series, i.e. the historical correlation commonly used by practitioners in the market.

References

1. Ballotta, L., Bonfiglioli, E.: Multivariate asset models using Lévy processes and applications. *The European Journal of Finance* Forthcoming (2014) .

A Bayesian estimate of the Pricing Kernel

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J.E.L. classification: G13, G19.

Abstract

We propose a Bayesian non-parametric approach to estimate the Pricing Kernel. The Bayesian non-parametric methodology does not impose any a priori restriction on the shape of the Pricing Kernel and allows to include the forward-looking information coming from the risk neutral density, modelled as the prior distribution of a Poisson Dirichlet Process, into the physical one. In this way the heterogeneity between the two measures, which is one of the main drivers of the pricing kernel puzzle, disappears and both densities are derived using a comparable information set.

The Bayesian Pricing Kernel, M_t^*, is defined as the present value of the ratio between the risk-neutral, $q(S_T|S_t)$, and the modified physical, $p^\dagger(S_T|S_t)$, densities conditional on the information set available at time t.

For each Wednesday of the sample period Jan.2002-Dec.2004 we fit a GJR GARCH model[3] to the historical daily log-returns of the S&P 500 and to the cross-section of the out-of-the-money call and put options written on the S&P 500 index. Depending on the measure (physical or risk-neutral) and on the type of innovations (Gaussian or Filtered Historical Simulated (FHS)[1]), we obtain four sets of GARCH parameters which are used to simulate $N = 50000$ asset prices from which we derive q and p, the risk-neutral and the physical densities. At this point the Bayesian component comes into play to estimate the modified physical density, $p^\dagger$, defined as the sum with Poisson Dirichlet (PD) weights of q^*, the risk neutral density rescaled for the equity premium, and p, the classical physical density, i.e.

$$p^\dagger = \frac{\alpha + Kd}{\alpha + n} q^* + \sum_{i=1}^{K} \frac{n_k - d}{\alpha + n} \delta_{X_i^*} \tag{1}$$

where $\alpha \in (-d, \infty)$ and $d \in [0, 1)$ are the concentration and the discount parameters of the PD Process, n and K respectively are the number of observations and clusters and $\delta_{X_i^*}$ is the dirac mass function applied to each unique simulated price X_i^*.

Starting values for the concentration parameter are borrowed from a previous work of Barone-Adesi et al.[2]. Moreover, as we can see from eq.(1), since a

larger value of α increases the weight associated to the prior (i.e. q^*) and implies a distribution more concentrated around its mean, we assume that this parameter is negatively correlated with the volatility level [1]. As regards the discount parameter, we set a starting value close to the upper bound of its support, thus reflecting the power law distribution of the data.

Even though the lack of call option data still causes irregularities in the right tail estimation (especially when τ is short), the proposed Bayesian Pricing Kernel satisfies the monotonicity requirement across almost sample dates and for any combination of time to maturity and type of innovation. Moreover, in the left tail the estimates exhibit isolated and bounded irregularities, thus implying that the proposed methodology is helpful in solving the put overpricing puzzle.

In a second stage, we performed the calibration of the model parameters, comparing three different approaches: (1) The Maximum Likelihood Estimation (Ewens Sampling Formula is used as the approximate Likelihood function), (2) The Bayesian Approach using the Random Walk Metropolis-Hastings to simulate the posterior distributions of α_t and d_t and (3) The Empirical Pricing Kernel Approach[4] which finds $\theta^* = (\alpha^*, d^*)| \min_\theta [1 - \mathbb{E}_t(M_t^*(\theta_t) R_{t+1})]^2$, where R_{t+1} is the return in the next period and M_t^* is the Pricing Kernel implied by the starting values of α and d.

In terms of resulting Pricing Kernel estimates, the Bayesian approach produces the best set of calibrated parameters compared to the alternative methodologies. The estimates become more regular in the tails and generally improve in terms of monotonicity; nevertheless the difference with the initial ones is not remarkable, thus meaning that the initial assumptions about the model parameters were suitable for the data.

References

1. Barone-Adesi, G., Engle, R. F., Mancini, L. : A GARCH option pricing model with filtered historical simulation. *Review of Financial Studies* (2008).
2. Barone-Adesi, G., Sala, C. :*The Pricing Kernel Anomaly: The Case of the Information that Did Not Bark*, Doctoral Dissertation. Swiss Finance Institute, Lugano (2015).
3. Glosten, L. R., Jagannathan, R., Runkle, D. E.: On the relation between the expected value and the volatility of the nominal excess return on stocks. *The journal of finance* **48** (1993) 1779-1801.
4. Rosenberg, J. V., Engle, R. F.: Empirical pricing kernels. *Journal of Financial Economics* **64** (2002) 341-372.

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[1] This relationship is formalized into the model by means of a switching regime model on the estimated unconditional long term GARCH volatility.

Volatility targeting and CPPI strategies

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J.E.L. classification: C61, C63, D81, G11.

Abstract

Recently, so called volatility control strategies and volatility target approaches to investment have gained a lot of interest, see among others [6][3].

These are essentially risk control strategies in which the exposure to the market is determined on the basis of current market conditions in terms of volatility levels.

We analyze the structure of these strategies and their performance under different market conditions. The effectiveness of these strategies in providing better risk-adjusted returns is considered as well as their ability to mitigate tail risk, see [10]. We consider their risk/reward performance in terms of generalized performance measures to take into account their ability to hedge against tail risk. In particular, we need performance measures which guarantee a degree of flexibility in dealing with the concept of risk and reward, and which allow us to include information on the whole distribution. To this aim, we consider the Omega ratio, [7], and the Φ ratio, [4].

The rule based target volatility approach allows for downside risk protection but, in our opinion, does not provide sufficient flexibility in controlling the risk-reward profile of the portfolio.

Furthermore, we compare them with a class of rule-based dynamic trading strategies widely used to control risk in portfolio allocation, namely the CPPI strategy and its extensions.

Constant Proportion portfolio insurance strategy (CPPI)is a dynamic trading strategy that rebalances the portfolio moving from a risky to a risk-less fund according to a predefined set of rules in order to keep the fund above a floor level allowing at the same time to capture market upside potential, see among others [2][8][1].

The interaction between volatility and portfolio insurance strategies has been widely studied in the literature (see, for example, [5]), also in connection with the 1987 market crash.

In this contribution, the goal is to analyze the interaction of these approaches in order to discuss a more flexible dynamic approach to asset allocation.

References

1. Basak, S., A Comparative study of Portfolio Insurance. *Journal of Economic Dynamics and Control* **26** (2002) 1217 - 1241.
2. Black, F., Perold, A.F., The theory of Constant Proportion Portfolio Insurance. *Journal of Economic Dynamics and Control* **16** (1992) 403-426.
3. Dopfel, F. E., Ramkumar, S.R., Managed volatility strategies: applications to investment policy. *The Journal of Portfolio Management* **Fall** (2013) 27-39.
4. Farinelli, S., Tibiletti, L. (2008): Sharpe thinking in asset ranking with one-sided measures. *European Journal of Operations Research*, 185, 1542-1547.
5. Frey, R., Stremme, A., Market volatility and Feedback effects from dynamic hedging. *Mathematical Finance* **7(4)** (1997) 351-374.
6. Hocquard, A., Ng, S., Papageorgiou, N., A constant-volatility framework for managing tail risk. *The Journal of Portfolio Management* **39(2)** (2013) 28-40.
7. Keating, C., Shadwick, W.F. (2002): A Universal Performance Measure, *Journal of Performance Measurement*, 6, 59-84.
8. Perold, A.F., Sharpe, W.F., Dynamic strategies for Asset Allocation. *Financial Analysts Journal* January/February (1988) 16-27.
9. Vanden, J.M., Portfolio Insurance and volatility regime switching. *Mathematical Finance* **16(2)** (2006) 387-417.
10. Xiong, J.X., Idzorek, T., Ibbotson, R.G. (2014): Volatility vs. Tail Risk: Which One is Compensated in Equity Funds? *Journal of Portfolio Management*, 40(2), 112-121.

A generalised linear model approach to predict the result of research evaluation

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J.E.L. classification: C44, C63.

Abstract

In the last decades the overall research performed by universities has been object of extensive analysis and evaluation by national agencies, in order to assess the quality of the research products and to allocate the national research funds to the universities themselves. The national agencies engage in long and costly procedures in order to provide their quality assessment. These procedure vary amongst countries, but they share some points in common: they heavily rely on peer-review, and the overall process takes several months in order to produce the eventual assessment. As a consequence, they are expensive and time-consuming. For these reasons, when they are performed on a regular basis, the period between two consecutive assessments may be significant (3 years in Germany; 6 years in the UK, etc.).

Some scholars have started to investigate whether automated methods can be used in order to predict the results of an evaluation exercise for universities. As we have remarked, the national research assessment is expensive and time-consuming, and a way of predicting its outcome could lead the universities to better allocate their resources and to develop proper operational strategies in a short time in order to improve their results. Therefore, a faster and automated approximation of the actual evaluation could be of interest to universities, national agencies, ranking agencies and students. The research in this direction is relatively new, and so far no exhaustive approaches have been proposed and tested a satisfactory manner which allow us to obtain general results. Amongst the proposed approaches, Mryglod et al.[**?**] have found a significant correlation between departmental h-indices and the outcome of the 2008 Research Assessment Exercise (RAE) in the UK. Starting from this result they have proposed to use this indicator (h-index) as a predictor for the outcome in the next research assessment. Indeed, the same authors shows in a later work that the proposed approach fails to anticipate the outcome of the 2014 Research Excellence Framework (REF), showing that these predictions failed to anticipate with accuracy both the overall REF outcomes and the movements in the ranking of the individual institutions relative to their positions in the previous Research Assessment Exercise [**?**].

On the other hand, it has been shown that there are no statistically significant differences between universities whose positions in the national ranking are adjacent, or even not far from each other[**?**]. Furthermore, often the exercises of research evaluation are focused on attributing each research product to a rating class rather than on assigning them a precise value (for instance REF classifies the research products submitted into five grade classes, decreasing in quality from world-leading to unclassified). Starting from these considerations, we try to devise a method to convert the outcome of the research assignment exercise into a rating scheme, and we investigate whether it is possible to forecast the rating of a given institution before it is even determined.

In our work, we set up an experimental analysis based on the use of a class of models that is widely used in non-life insurance mathematics: the generalised linear models (GLM)[**?**]. For the problem at hand, we use GLM models in order to predict both ranking and rating of universities. To this aim, GLM models may be useful since they represent an extension of ordinary linear regression and allow us to use non-normal distributions by defining a link function to create a relationship between the linear prediction and the model output. GLM models prove to be able to provide us with robust results, and we compare different models in order to determine which one gives the best predictions. As for the benchmark, we use publicly available information, such as the departmental h-indices, which are frequently updated. On the other hand, it could be worth taking into account the rating (and ranking) information relative to the previous research evaluation, even if they are by this time dated. In effect, subsequent evaluations generally do not change dramatically the ranking assigned to universities, so the last known outcome may still give useful information. In order to test the accuracy of the proposed algorithms, we apply our approach to the same data set on REF used by Mryglod et al.[**?**,**?**].

References

1. Mryglod, O.,Kenna, R., Holovatch, Yu., Berche, B.: Predicting results of the Research Excellence Framework using departmental h-index. *Scientometrics* **102:3** (2015) 2165-2180.
2. Mryglod, O., Kenna, R., Holovatch, Yu., Berche, B.: Predicting results of the research excellence framework using departmental h-index: revisited. *Scientometrics* **104:3** (2015) 1013-1017.
3. Claassen, C.: Measuring university quality. *Scientometrics* **104:3** (2015) 793-807.
4. McCullagh, P., Nelder, J.: Generalized Linear Models, Second Edition. Chapman and Hall–CRC Monographs on Statistics and Applied Probability. Springer Science and Business Media, Dordrecht, The Netherlands (1989).

Credit and systemic risks in the financial services sector: evidence from the 2008 global crisis*

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J.E.L. classification: C32, G21, G22.

Abstract

The financial crisis of 2008 highlighted serious negative consequences of the interconnectedness of large financial institutions and their increased credit risk. Indeed, the crisis demonstrated the lack of adequate credit and systemic risk monitoring within the financial services industry.

According to Billio *et al.* [2], there are four major determinants of financial crises (the so-called "L"s): leverage, losses, linkages and liquidity. It is challenging to account for the four "L"s simultaneously within a single framework. Efficient estimation procedures and realistic datasets are two noticeable limitations. In this study, we construct a multivariate credit risk model that accounts for firm-specific financial health. It captures three out of the four determinants: leverage, losses and linkages.

More precisely, to model the leverages, losses and linkages adequately, a regime switching extension of the multivariate hybrid credit risk model of Boudreault *et al.* [3] is proposed: it allows for firm-specific statistical regimes that accommodate for changes in the leverage uncertainty, pairwise regime-dependent correlations of leverage co-movements and an endogenous stochastic recovery rate that is negatively related to the default probabilities and therefore impacts on loss distribution. Regime-switching dynamics are required to capture the various changes in behaviour through time, and more particularly during crises.

Estimation of the model's parameters is a crucial step to adequately measure both credit and systemic risks. We develop a two-stage filtering procedure

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extending the detection-estimation algorithm of [5] and the unscented Kalman filter. In addition to being adequate from a statistical point of view, this filter allows us to find firm-specific model parameters based on maximum likelihood estimators.

Using weekly credit default swap premiums for 35 financial firms, we analyze the credit risk of each of these companies and their statistical linkages, placing special emphasis on the 2005–2012 period. The use of market data is worthwhile: CDS premiums contain forward-looking information and are updated frequently by market participants as the information becomes available. Accordingly, they can better detect changes in solvency or occurence of crises.

To the best of our knowledge, this study is one of the first to investigate the individual solvency of 35 financial firms during and after the crisis. In particular, we find that AIG's 1-year default probability spikes to 42% on September 10, 2008, a week before its near-default. Our results also show a clear increase in insurers and banks' default probabilities during the turmoil.

Linkage varies over time. We find evidence of larger correlations between firm leverage co-movements during the high-volatility regime which suggests the existence of greater interconnectedness during the last crisis. Moveover, the regime-dependent linkage structure varies across subsectors.

Finally, as the model captures firm-specific credit risk and dependence across the firms, it serves as a building block to construct a systemic risk measure inspired from [1]. We find increases in systemic risk contributions for both insurance and banking subsectors during the crisis period. In line with Chen *et al.* [4], we detect a unidirectional causal effect from banks to insurers when accounting for heteroskedasticity. Therefore, even if our methodology differs and our data extends over the aftermath of the crisis, our results suggest that the direction of the causal relationship is robust.

References

1. Acharya, V., Pedersen, L.H., Philippon, T, Richardson, M.: Measuring systemic risk. *Working paper* (2010) 1–46.
2. Billio, M., Getmansky, M., Lo, A.W., Pelizzon, L.: Econometric measures of connectedness and systemic risk in the finance and insurance sectors. *Journal of Financial Economics* **104** (2012) 535–559.
3. Boudreault, M., Gauthier, G., Thomassin, T.: Contagion effect on bond portfolio risk measures in a hybrid credit risk model. *Finance Research Letters* **11** (2014) 131–139.
4. Chen, H., Cummins, J.D., Viswanathan, K.S., Weiss, M.A.: Systemic risk and the interconnectedness between banks and insurers: An econometric analysis. *Journal of Risk and Insurance* **81** (2014) 623–652.
5. Tugnait, J.K.: Detection and estimation for abruptly changing systems. *Automatica* **18** (1982) 607–615.

Hierarchical Lee-Carter model estimation through data cloning applied to demographically linked populations

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J.E.L. classification: C53, G22.

Abstract

Lee and Carter (1992) proposed a model to forecast mortality as a function of a time-varying index. This paper was the seminal work for further developments in the estimation of future mortality. The model deals with $m_x(t)$, the central death rate for age x in year t (it is calculated as the ratio of deaths to mid-year population size for a given interval of age and time), and its specification is the following:

$$\log\left[m_x(t)\right] = \alpha_x + \beta_x\kappa_t + \varepsilon_{x.t}.$$

where α_x parameters describe the pattern of the average mortality at each age, while β_x parameters describe deviations from this average pattern when κ_t varies. Both sets of parameters, $\{\alpha_x\}$ and $\{\beta_x\}$ are independent of time. The variable, κ_t, is an index. It can be expressed as a time series process and it describes the change in the level of mortality over time. This index is an unobservable variable, so it must be estimated. Finally, $\varepsilon_{x.t}$ is an error term.

On the other hand, relevant information based on historical information or on skilled opinions are used in Bayesian models to improve the estimation.

In our working paper, we propose a hierarchical specification of the Lee-Carter model for a group of countries and we assume that there is a common latent mortality factor for all of them. The reason of this specification relies on the fact that some groups of countries are linked not only economically, but also socially and even demographically. And this fact can be exploited when trying to forecast the death rates of their populations. This link is quite interesting to estimate the parameters of the model because it allows to take advantage of the whole set of information, that is, the forecasts of a certain country are calculated not only based on its death rates but also on those of the rest of the considered linked populations.

Bayesian methodology is a very effective way to deal with hierarchical models. However, this scheme is limited by the fact that it is often necessary that the analyst determines the prior distributions for all parameters and hyperparameters of the model. Therefore, we introduce an estimation procedure for this kind of structures by means of a data cloning methodology. The two seminal papers about this methodology are Lele et al. (2007) and Lele et al. (2010), with applications in complex ecological models. To our knowledge, this is the first time that this methodology is used in the actuarial field. It allows approximating the maximum likelihood estimates, which are not affected by the prior distributions assumed for the calculus. Thus, data cloning is an alternative to surpass the previous limitation.

Finally, we apply the methodology to France, Italy, Portugal and Spain data. In order to check the validity of the forecasts, the sample has been divided into two sets. The first one is devoted to estimate the parameters, whereas the second one is used to contrast the accuracy of the results. The forecasts obtained using this methodology can be considered as very satisfactory: the model is able to rightly predict the central death rates rates in all cases, using 95% approximated prediction intervals.

References

1. Lee, R., Carter, L.: Modeling and forecasting U.S. mortality. *Journal of the American Statistical Society, 87* (1992) 659-675.
2. Lele, S., Dennis, B., Lutsche, F.: Data cloning: easy maximum likelihood estimation for complex ecological models using Bayesian Markov Chain Monte Carlo methods. *Ecology letters, 10* (2007) 551-563.
3. Lele, S., Nadeem, K., Schmuland, B.: Estimability and likelihood inference for generalized linear mixed models using data cloning. *Journal of the American Statistical, 105* (2010) 1617-1625.

On L_p-quantiles

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J.E.L. classification: C11, C22, D81.

Abstract

Financial institutions such as banks and insurance companies, are required to hold some safely invested capital in order to be acceptable from a regulatory perspective. The most well known risk measures used to compute such a risk capital are Value-at-Risk (VaR) and Expected Shortfall (ES).

ES is often regarded as a better risk measure than VaR because it is *coherent*, in particular subadditive, see [2] and it considers the extreme left tail of the distribution. The recent literature on risk measurement has highlighted that, from a statistical point of view, ES presents some important deficiencies. In particular [7] pointed out that ES, contrary to VaR, does not satisfy the so-called *elicitability property.* A risk measure ρ is elicitable if it can be defined as the unique minimiser of a given expected loss function L:

$$\rho(Y) = \arg\min_{m\in\mathbb{R}} E[L(Y-m)]. \tag{1}$$

This property has attracted major attention in the recent literature because the empirical expected loss can be used as a natural statistics to perform the backtesting of the risk measure and to consistently rank different risk measure forecasts. As a result of the debate between VaR and ES, another risk measure has attracted major attention as a valid alternative to VaR and ES, namely the *expectiles.* Expectiles were introduced by [1] and [8]. They are defined as the unique minimiser of an asymmetric squared function:

$$\mu_\tau(Y) = \arg\min_{m\in\mathbb{R}} E\left[\left|\tau - \mathbb{I}_{\{Y-m<0\}}\right| (Y-m)^2\right], \quad \text{for all } \tau \in (0,1), \tag{2}$$

for $\tau = 1/2$, $\mu_{1/2}(Y) = E[Y]$. [4] showed that they are coherent risk measures for $\tau \in (0, \frac{1}{2})$ and according to [9], [3] and [6] they are the *unique* elicitable coherent risk measure.

In the present contribution we work in the same direction and consider the class of L_p-*quantiles* introduced by [5]. For a random variable Y with cumulative

distribution function F_Y the L_p-*quantile* at level α is defined as

$$\rho_{\alpha,p}(Y) = \arg\min_{m\in\mathbb{R}} E\left[\left|\alpha - \mathbb{I}_{\{Y-m\}}\right| (Y-m)^p\right] \quad \text{for all } \alpha\in(0,1), p\in\mathbb{N}\setminus\{0\}. \tag{3}$$

Clearly Expectiles coincide with the L_2-quantiles. L_p-quantiles represent an important class of elicitable risk measures. We investigate their properties and financial meanings and explain their link with conditional tail moments. We show that L_p-quantiles can be written as the unique solution of an equation involving all the truncated moments $G_{j,Y}(m) = \int_{-\infty}^{m} y^p \mathrm{d}F_Y(y)$ for all $m\in\mathbb{R}$ and $j = 0, 1, \ldots, p-1$. As a main contribution we prove that similarly to expectiles, L_p-quantiles coincides with quantiles for a t-distribution with p degrees of freedom. In the second part of the paper we show how it is possible to properly estimate L_p-quantiles using a Bayesian inference approach and provides numerical examples.

References

1. Aigner, D.J. , Amemiya, T. and Poirier, D.J.: On the estimation of production frontiers: Maximum Likelihood Estimation of the parameters of a discontinuous density function. *International Economic Review* **17** (1976) 377-396.
2. Artzner, P., Delbaen, F., Eber, J.-M. and Heath, D.: Coherent measures of risk. *Mathematical Finance* **9** (1999) 203-228.
3. Bellini, F. and Bignozzi, V.: On elicitable risk measures. *Quantitative Finance* **15** (2015) 725-733.
4. Bellini, F., Klar, B., Müller, A. and Rosazza Gianin, E.: Generalized quantiles as risk measures. *Insurance: Mathematics and Economics* **54** (2014) 41-48.
5. Chen, Z.: Conditional L_p-quantiles and their application to the testing of symmetry in non-parametric regression. *Statistics and Probability Letters* **29** (2001) 107-115.
6. Delbaen, F., Bellini, F., Bignozzi, V., Ziegel, J.F.: On convex risk measures with the CxLS property. *Finance and Stochastics* (2015) forthcoming.
7. Gneiting, T.: Making and evaluating point forecasts. *Journal of the American Statististical Association* **106** (2011) 746-762.
8. Newey, W. and Powell, J.: Asymmetric least squares estimation and testing. *Econometrica*, **55** (1987) 819-847.
9. Ziegel, J.: Coherence and elicitability. *Mathematical Finance* (2014) forthcoming.

Assessing market (in)efficiency

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J.E.L. classification: C22, C62.

Abstract

The notion of informational efficiency for financial markets represents one of the cornerstones on which the whole asset pricing theory rests. It requires that the price S_t of an individual asset is expected to discount all information $\mathcal{F}_t$ accumulated up to time t, as a consequence of the quick and wide spread of news, which should ensure that eventual departures from equilibrium values cannot last for long. Originated by the more general notion of equilibrium, efficiency is generally introduced and tested in terms of the expected value of properly discounted payoffs [1]. Thus, with respect to the filtered probability space $(\Omega, \mathcal{F}_t, (\mathcal{F})_{0\leq t\leq T}, \mathbb{P})$, the condition requires that for $t < \tau < T$

$$S_t = \mathbb{E}_t\left(Y_{t,\tau} X_\tau\right) \tag{1}$$

or, equivalently, that

$$\mathbb{E}_t\left(Y_{t,\tau}\frac{X_\tau}{S_t}\right) = 1. \tag{2}$$

In words, the current price of a financial asset equals the conditional expectation of its payoff X_τ discounted by the stochastic discount factor $Y_{t,\tau}$ that accounts for the risk premium. Since

$$\mathbb{E}_t\left(Y_{t,\tau}(1 + r_{t,\tau})^{\tau-t}\right) = 1 \tag{3}$$

subtracting (3) from (2) yields to

$$\mathbb{E}_t\left(Y_{t,\tau}\left(\frac{X_\tau}{S_t} - (1 + r_{t,\tau})^{\tau-t}\right)\right) = 0.$$

For $\tau = t + 1$, setting $R^*_{t,t+1} = \frac{X_{t+1}-S_t}{S_t} - r_{t,t+1}$, the equation above turns to

$$\mathbb{E}_t\left(Y_{t,t+1} \cdot R^*_{t,t+1}\right) = 0, \tag{4}$$

stating that the conditional expected excess returns equals zero. Traditionally, financial literature tests efficiency through (4), but since the model-dependent process that generates the risk-premium is not observable, the EMH can be tested ultimately only jointly with a model providing $Y_{t,\tau}$ [3]. Since equation (4) implies

$$\mathbb{E}_t(R^*_{t,t+1}) = -(1 + r_{t,t+1}) \cdot \mathrm{Cov}(R^*_{t,t+1}, Y_{t,t+1}) \tag{5}$$

by itself the predictability of returns (i.e. the controversial failure of the random walk model) does not prove market inefficiency, since it suffices the expected conditional return to comply with (4) in order to save both efficiency and non-random walk models.

The idea that financial markets self-regulate towards no-arbitrage prices is dramatically called into question by the repeated occurrence of financial crises, bubbles and crashes, which take place at frequencies and orders of magnitude much higher than those expected by the Efficient Market Hypothesis(EMH). The accumulation of empirical evidence contrary to the EMH has gone hand in hand with the development of the Behavioral Finance (BF). An evolutionary synthesis of both has been proposed by Lo (2004) [2] with his Adaptive Market Hypothesis (AMH). He groups market participants into species, each behaving in a common manner. Market efficiency can spring from the competition among the species (or the members of a single species). Market loses efficiency when few species are in competition for rather abundant resources. As a consequence, Lo states that "market efficiency cannot be evaluated in a vacuum, but is highly context-dependent and dynamic".

The main purpose of this work is precisely to make the previous statement testable, by means of a quantitative assessment of the pointwise degree of market (in)efficiency.

Due to the reasons above discussed, instead of testing efficiency through the predictability of returns, we will assess it through the regularity of the price process trajectories.

References

1. Fama, E.F.: Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance* **13(2)** (1970) 301-330.
2. Lo, A.W.: The adaptive markets hypothesis: market efficiency from an evolutionary perspective*Journal of Portfolio Management* **30** (2004) 15-29.
3. Timmermann, A., Granger, C.W.J.: Efficient market hypothesis and forecasting*International Journal of Forecasting* **20** (2004) 15-27.

Continuous time semi-Markov inference of biometric laws associated with a Long-Term Care Insurance portfolio

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J.E.L. classification: G22.

Abstract

Unlike the mortality risk on which actuaries have been working for more than a century, the long-term care risk is young and as of today hardly mastered. Semi-Markov processes have been identified as an adequate tool to study this risk. Nevertheless, access to data is limited and the associated literature still scarce. Insurers mainly use discrete time methods directly inspired from the study of mortality in order to build experience tables. Those methods however are not perfectly suited for the study of competing risk situations.

Our presentation aims at providing a theoretical framework to estimate biometric laws associated with a long-term care insurance portfolio. The presented method relies on a continuous-time semi-Markov model with three states: autonomy, dependency and death. The dependency process is defined using its transition intensities. We provide a formula to infer the mortality of autonomous people from the general population mortality, on which we ought to have more reliable knowledge. We then propose a parametric expression for the remaining intensities of the model. Incidence in dependency is described by a logistic formula. Under the assumption that the dependent population is a mixture of two populations with respect to the category of pathology that caused dependency, we show that the resulting intensity of mortality for dependent people takes a very peculiar form, which is semi-Markov. Estimation of parameters relies on the maximum likelihood method. A parametric approach eliminates issues related to segmentation in age categories, smoothing or extrapolation at higher ages. While creating model uncertainty, it proves very convenient for the practitioner. Finally, we provide an application using data from a real long-term care insurance portfolio.

Keywords: Long-Term Care Insurance, continuous time semi-Markov process, competing risks, maximum likelihood, mixture model, parametric model.

References

1. Brass, W.: Mortality Models and Their Uses in Demography. *Transactions of the Faculty of Actuaries* **33** (1971) 123-142.
2. Christiansen, M. C.: Multistate models in health insurance. *Advances in Statistical Analysis* **96(2)** (2012) 155-186.
3. Cox, D. R. and Oakes, D.: *Analysis of survival data*. CRC Press (1984).
4. Hannerz, H.: An extension of relational methods in mortality estimation. *Demographic Research* **4(10)** (2001) 337-368.
5. Perks, W.: On some experiments in the graduation of mortality statistics. *Journal of the Institute of Actuaries* **63(1)** (1932) 12-57.
6. Rickayzen, B. D. and Walsh, D. E. P.: A multi-state model of disability for the United Kingdom: Implications for future need for Long-Term Care for the elderly. *British Actuarial Journal* **8** (2002) 341-393.

Markov switching GARCH models: filtering, approximations and duality

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J.E.L. classification: C01, C13, C58.

Abstract. Time varying volatility is one of the main property of many financial time series. Moreover, describing and, where possible, forecasting volatility is a key aspect in financial economics and econometrics. A popular class of models which describe time-varying volatility are Generalized Autoregressive Conditional Heteroschedasticity (GARCH) models. GARCH models [1] [9] [8] describe the variance as a linear function of the squares of past observations, so that one type of shock alone drives both the series itself and its volatility. One potential source of misspecification derives from the fact that structural forms of conditional means and variances are relatively inflexible and held fixed throughout the sample period. In this sense, they are called *single-regime* models since a single structure for the conditional mean and variance is assumed. To allow more flexibility, the assumption of a single regime could be relaxed in favour of a *regime-switching* model. The coefficients of this model are different in each regime to account for the possibility that the economic mechanism generating the financial series undergoes a finite number of changes over the sample period. These coefficients are unknown and must be estimated, and, although the regimes are never observed, probabilistic statements can be made about the relative likelihood of their occurrence, conditional on an information set. A well-known problem to face when dealing with the estimation of Markov Switching (MS) GARCH models is the path dependence. [2] and [5] have argued that MS GARCH models are essentially intractable and impossible to estimate since the conditional variance depends on the entire path history of the data. That is, the distribution at time t, conditional on the current state and on available information, is directly dependent on the current state but also indirectly dependent on all past states due to the path dependence inherent in MS GARCH models. This is because the conditional variance at time t depends upon the conditional variance at time $t-1$, which depends upon the regime at time $t-1$ and on the conditional variance at time $t-2$, and so on. Hence, the conditional variance at time t depends on the entire sequence of regimes up to time t. Some methods are proposed in the literature to overcome the problem of path dependence present in MS GARCH. The trick is mainly found in adopting different specifications of

the original MS GARCH model. Some authors propose Quasi Maximum Likelihood (QML) procedures of a model which allows similar effects of the original one. Models which elude in this way the path dependence problem are proposed by [4], [3] and [6], among others, and are known as collapsing procedures. [4] proposes a model in which path dependence is removed by aggregating the conditional variances from the regimes at each step. This aggregated conditional variance (conditional on available information, but aggregated over the regimes) is then all that is required to compute the conditional variance at the next step. The contribution of our paper is to give a unique framework to reconcile MS GARCH estimation obtained by the above auxiliary models from one side, and a filtering algorithm from the other. This relationship provides the missing link to justify the validity of approximations in estimating MS GARCH models. The use of filtering is a flexible approach and it allows the estimation of a broad class of models that can be put in a switching state space form. However, to make the filter operable, at each iteration we need to collapse M^2 posteriors (where M is the number of switching regimes) in M of it, employing an approximation as suggested by [7]. Then, QML estimation of the model recovers the unknown parameters.

References

1. Bollerslev, T.: Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics* **52** (1986) 5-59.
2. Cai, J.: A Markov model of unconditional variance in ARCH. *Journal of Business and Economic Statistics* **12** (1994) 309-316.
3. Dueker, M.J.: Markov Switching in GARCH Processes and Mean Reverting Stock Market Volatility. *Journal of Business and Economic Statistics* **15**(1) (1997) 26-34.
4. Gray, S.F.: Modelling the Conditional Distribution of Interest Rates as a Regime-Switching Process. *Journal of Financial Economics* **42** (1996) 27-62.
5. Hamilton, J.D., and Susmel, R.: Autoregressive conditional heteroskedasticity and changes in regime. *Journal of Econometrics* **64** (1994) 307-333.
6. Klaassen, F.: Improving GARCH Volatility Forecasts with Regime-Switching GARCH. *Empirical Economics* **27**(2) (2002) 363-394.
7. Kim, C.J.: Dynamic Linear Models with Markov Switching. *Journal of Econometrics* **64** (1994), 1-22.
8. Lamoureux, C.G., and Lastrapes, W.D.: Persistence in variance, structural change, and the GARCH model. *Journal of Business and Economic Statistics* **8** (1990) 225-234.
9. Nelson, D.B.: Stationarity and persistence in the GARCH(1,1) model. *Econometric Theory* **6** (1990) 318-344.

von Neumann entropy for financial interconnectedness and systemic risk

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J.E.L. classification: C32, G01, G20, G28, G32.

Abstract

Given the relevance of the latest financial and sovereign crises, systemic events are now deeply analysed by scholars and policy makers. As a matter of fact, the consequences of systemic risk are relevant both for the stability of the financial and banking system and in terms of diversification in an investor perspective [5]. Linkages among financial institutions using pairwise Granger causality tests have been used to extract the financial network in order to detect significant linkages among financial institutions and to describe which ones are systemically important [2]. Recently, entropy measures have been involved in systemic risk measurement for propagation of financial contagion [7] and as early warning indicator for banking crises [1]. Moreover, a strand of literature on complex network has focused on the association of the network with density matrix of a quantum state [6], in particular, using the von Neumann entropy as an indicator for complexity. Most of this literature has focused on undirected networks and has used both the adjacency matrix and the Laplacian matrix to obtain the association with a quantum state even if there were also some attempts to adapt the framework to directed networks [8]. The peculiarity of directed networks and in particular their asymmetry requires some care and redefinition of the Laplacian [4]. In particular, the combinatorial Laplacian L for directed networks is formulated in terms of out degrees $dout_i$, Perron vector ϕ of the transition matrix P, that is related to eigenvector centralities, and can be soundly computed only for strongly connected components, and can be related to the circulation on the graph [4].

$$dout_i = \sum_{j=1}^{N} A_{ij}; \quad P_{ij} = \begin{cases} \dfrac{A_{ij}}{dout_i} & \text{if } A_{ji} \neq 0 \\ 0 & \text{if } A_{ji} \neq 0 \end{cases} \tag{1}$$

$$\phi P = P, \quad \varPhi = \operatorname{diag}(\phi) \quad L = \varPhi - \frac{\varPhi P + P^{*}\varPhi}{2} \tag{2}$$

It represents in this way a theoretically founded combination of several measures that have proven relevant for systemic risk. Even if it is symmetric it is not

positive definite and cannot directly used for obtaining a density matrix as it was showed possible in the undirected case. Instead putting together [3, 6] we can obtain a density matrix ρ, based on the Laplacian but correct for directed graphs, and its Von Neumann entropy $S(\rho)$from the normalized square

$$\rho = \frac{LL'}{\text{trace}\,(LL')} \tag{3}$$

$$S(\rho) = -\text{trace}\,(\rho \log(\rho)) \tag{4}$$

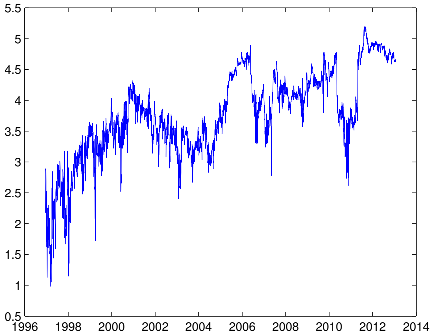

Fig. 1. von Neumann Entropy for the European financial network (Datastream/Worldscope) from 1996 to 2013.

References

1. Billio, M., Casarin, R., Costola, M., & Pasqualini, A: An Entropy-Based Early Warning Indicator for Systemic Risk. University Ca'Foscari of Venice, Dept. of Economics Research Paper Series. **9** (2015)
2. Billio, M., Getmansky, M., Lo, A. W., & Pelizzon, L.: Econometric measures of connectedness and systemic risk in the finance and insurance sectors. *Journal of Financial Economics* **104(3)** (2012) 535-559.
3. Samuel L Braunstein, Sibasish Ghosh, and Simone Severini. The laplacian of a graph as a density matrix: a basic combinatorial approach to separability of mixed states. *Annals of Combinatorics*, 10(3):291–317, 2006.
4. Fan Chung. Laplacians and the cheeger inequality for directed graphs. *Annals of Combinatorics*, 9(1):1–19, 2005.
5. Das, S. R., & Uppal, R.: Systemic risk and international portfolio choice. *The Journal of Finance* **59(6)** (2004) 2809-2834.
6. Silvano Garnerone, Paolo Giorda, and Paolo Zanardi. Bipartite quantum states and random complex networks. *New Journal of Physics*, 14(1):013011, 2012.
7. Paltalidis, N., Gounopoulos, D., Kizys, R., & Koutelidakis, Y.: Transmission Channels of Systemic Risk and Contagion in the European Financial Network. *Journal of Banking & Finance* **61(s1)** (2015) S36-S52.
8. Cheng Ye, Richard C Wilson, César H Comin, Luciano da F Costa, and Edwin R Hancock. Approximate von neumann entropy for directed graphs. *Physical Review E*, 89(5):052804, 2014.

Low default portfolios: implied rating estimation and long-run default forecasting

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J.E.L. classification: C13, C23, C33, C51, C52, G24.

Abstract

While an extensive academic and practitioners literature exists on rating and probability of high-default portfolios, few studies have been found on rating estimation for low default portfolios.

In this paper we estimate a 3-years rating for financial and non financials counterparties, starting from a sample of firms with a consensus rating and the results have been applied to an enlarged sample of external counterparties with at 10 years history (from 2003 to 2013) and default experience (with the default event considered when Bankruptcy or Default of Payments occurred). The External sample of Non-Financial Corporates is composed by almost 3 thousand counterparties, with less than 130 in a default status. The External Sample of Financial Institutions is composed by almost 4 thousand counterparties, with less than 100 in a default status.

The application of the rating model to the external sample returns an Implicit Rating, based on GOLR model, for each of the counterparty:

$$PR_{ClassN} = \frac{1}{1 + e^{(\alpha_{classN} + \beta X')}} \tag{1}$$

$$PR_{Class1} = 1 - PR_{ClassN} - PR_{ClassN-1} - \ldots - PR_{Class2} \tag{2}$$

where:

- PR_{ClassN}, is the probability that the counterpart belongs to rating class N.
- α_{classN}, is the intercept value related to the rating class N
- β, and X' are the vector of coefficients and the vector of predictor variables

All these information let the rating to be accurate and forecast the long-run implicit default probability for each rating class. In order to backtest the model,

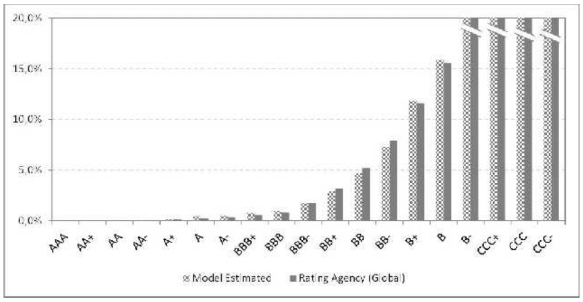

Fig. 1. Probabilities of Default Distribution by Rating Class

a benchmark analysis with data of one of the main rating agencies has been performed in order to assess the goodness of our forecasting:

Given the portfolio with a higher concentration of counterparties (both Non Financial Corporates and Financial Institutions) on investment grades, it can be observed, that on these sub-categories (from AAA to BBB-) the default rates deriving from the model estimated are totally aligned to the ones provided by Rating Agency. On speculative grades some differences are registered: this is due to a lower model accuracy given the low number of counterparties in the speculative grade area used to test the rating model, as the target clients (used to test the rating models) were mainly represented by large Non-Financial Corporates and Financials Institutions.

References

1. Bohn J.R., and Stain R.M. *Active Credit Portfolio Management in Practice.* John Wiley & Sons, Inc. (2009).
2. Burgt van der, M.: Calibrating Low-Default Portfolios, using the Cumulative Accuracy Profile. *Journal of Risk Model Validation* **4** (2008) 1-17.
3. Engelmann, B., and Porath D.: *Do not Forget the Economy when Estimating Default Probabilities.* Willmott Magazine **2** (2012) 70-73.
4. Iqbal, N., and Ali, A.: *Estimation of Probability of Defaults (PD) for Low Default Portfolios: An Actuarial Approach.* ERM Symposium (2012)
5. Jafry, Y., Shuermann,T.: *Measurement and Estimation of Credit Migration Matrices.* Journal of Banking and Finance **28** (2004) 2603-2639.
6. Kiefer, N.M.: *Default Estimation, Correlated Defaults, and Expert Information*, Journal of Applied Econometrics **26** (2011) 173-192.
7. Kiff, J., Kisser, M., and Schumacher, L.: *Rating Through-the-Cycle: What does the Concept Imply for Rating Stability and Accuracy?* IMF Working Paper **13** (2013).
8. Konrad, M.P.: *The Calibration of Rating Models.* Tectum-Verlag (2014).
9. Tasche, D.: *The art of PD curve calibration.* Journal of Risk Management **4** (2013) 63-103.
10. Tasche, D.: *Bayesian Estimation of probabilities of default for low default portfolios.* Journal of Risk Management **3** (2013) 302-326.

Fast proxy models and applications

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J.E.L. classification: C02, C13, C55, C81, G11, G12.

Abstract

Financial firms are required to provide information and reassurance that they have the capital strength to cope with the uncertainty of the future events. Besides being a regulatory exercise Insurance Firms need to compute several complex calculations in short times. Stress tests and the Own Risk and Solvency Assessment (ORSA) determine how insurance companies are going to carry on their business. Stress tests became a best practice after the financial crisis, see, e.g., [3, 4], when measure such as the VaR started to show reliability faults under extreme conditions, so that the International Monetary Fund (IMF), the European Banking Authority (EBA) and the European Systemic Risk Board (ESRB), developed a framework for the periodic running of stress test to measure the bank resilience, see, e.g., [2]. Analogously, insurances will need to forecast their capital according to a newer framework. In such a scenario insurance companies will also have to take care about, e.g., projections of Profits and Losses (P&L), definition of budgeting, and pricing strategies. Within the aforementioned a top down hierarchy of variables has been taken into account. At a first level the macro economic variables, such as, e.g., Gross Domestic Product (GDP), oil price, inflation rate, etc., are taken into consideration composing a typical set of about one dozen of variables, varying in time, summarized by a vector, let us say $\mathbf{m} = \mathbf{m}(t)$. Such variables are often reffered to as the *risk drivers*; then a set of intermediate variables that have a more granular structure, e.g., a set of financial indices, let us call it $\mathbf{v} = \mathbf{v}(t)$, depending on the risky drivers in the top down approach. Under a suitable general model, we will have $\Delta\mathbf{v}(t) = f\left(\Delta\mathbf{m}^t; B\right)$, where $\mathbf{m}^t$ stand for $(\mathbf{m}_s : s \leq t)$. The set of the actual *risk factors*, i.e. the variables that actually affect the single bank positions in their value and risk, therefore generating losses. In such a case we span from the customers' Default Probabilities (PDs), to the underlying prices, to the derivatives' volatilities, etc. The vector $\mathbf{f} = \mathbf{f}(t)$ concerns several thousand (until millions)

risk factors, each of which is linked to the intermediate variables by dynamic relation as $\mathbf{f}(t) = g(\mathbf{v}(t); \Theta)$. Eventually, each bank position value Mark to Market (MtM) depends on risk factors through relations as: $MtMi = \phi\left(\mathbf{f}_i(t)\right)$. Most of the aforementioned models are linear, being also studied by a sensitivity approach, mainly in the f-system of functions. Moreover, the g-dependencies are almost always nonlinear, reflecting instruments' financial clauses, or the links between the risk parameters and the portfolio risk figures. The goal is to provide suitable approximations for the related stress test output $\phi\left(\mathbf{f}_i(t)\right)$, given the analytical features of the inputs $\mathbf{m}$. In particular, see, e.g., [5, 6], stress test provides 3 main area of deployment: Firms: own stress testing, risk, portfolio or institution ORSA, EBA; Supervisors: Micro-prudential stress test - risk, portfolio or institution; International Authorities: Macro-Prudential - Institution. Every exercise has a different scope, while Firms are interesting in risk management and planning, supervisor are interested in law impact, action, and early warning. Macro-prudential authorities are concern about global financial stability. Given the currently regulatory framework, one off exercise will be required more often and a continuous and dynamic monitoring of the Balance sheet became a competitive advantage. Regulation is changing and required Board of insurance validate dynamic assumptions on the underlying models. Standard Formula and Internal Model users are facing hard time to find the right balance between the pureness of the mathematical framework and the simplicity and responsiveness of the business requirements. In our work we will exploit regression based models in general and proxy models in particular, to face relevant case studies coming from real world insurance business arena, see also [1]. In particular we consider a practical case where there are 3 principal components to model interest rates, and we take into account equities, their volatilities, lapses and currencies. The main advantage is to overcome the difficulties characterizing the study of terms $\phi(\mathbf{f}_i(t))$, where ϕ are rather complex and depend on $\mathbf{f}_i$-s that can be simple (of linear or at most polynomial type) but very numerous (even thousands millions), by studying a selection of suitable risk factors. The latter, of course, have to be chosen in order to maintain a high grade of information about the original model, hence they have to be the most significant risk factors, then techniques like the PCA can be fruitfully applied.

References

1. Asteriou, A., Hall, S. G., : Applied Econometrics, Palgrave Macmilian, (2011)
2. Basel Committee on Banking Supervision (BCBS) : Principles for sound stress testing practices and supervision, BCBS paper 147 (2009)
3. Gilson, R., J. , Kraakma, R. : Market Efficiency after the Financial Crisis: It's Still a Matter of Information Costs, SSRN (2014)
4. Krapl, A., A.: Corporate international diversification and risk, International Review of Financial Analysis, Vol.37, (2015)
5. Montesi, G., Nicastro, P., Papiro, G. : Stress testing: a stochastic simulation model and a comparison with 2014 Eba/Ecb, Bancaria (2015)
6. Ong, L., Maino, R. , Duma, N. : Into the great unknown: Stress testing in weak data, In: IMF Working Paper, WP/10/282 (2010)

A backward Monte Carlo approach to exotic option pricing

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J.E.L. classification: C63, G12, G13.

Abstract

We propose a novel algorithm which allows to sample paths from an underlying price process in a local volatility model and to achieve a substantial variance reduction when pricing exotic options. The new algorithm relies on the construction of a discrete multinomial tree. The crucial feature of our approach is that – in a similar spirit to the Brownian Bridge – each random path runs backward from a terminal fixed point to the initial spot price. We characterize the tree in two alternative ways: in terms of the optimal grids originating from the Recursive Marginal Quantization algorithm (henceforth RMQA), or following an approach inspired by the finite difference approximation of the diffusion's infinitesimal generator we name Large Time Step Algorithm (henceforth LTSA). We assess the reliability of the new methodology comparing the performance of both approaches and benchmarking them with competitor Monte Carlo methods.

In more detail, a discrete-time Markov Chain approximation of the asset price dynamics can be achieved by introducing at each time step two quantities: (i) a grid for the possible values that the can take, and (ii) the transition probabilities to propagate from one state to another state. Among the approaches discussed in the literature for computing these quantities, in the present paper we analyse and extend two of them.

The first approach quantizes via the RMQA the Euler-Maruyama approximation of the Stochastic Differential Equation (SDE) modelling the underlying

asset price. The RMQA has been introduced in [1] to compute vanilla call and put options prices in a pseudo Constant Elasticity of Variance (CEV) model. In [2] authors employ it to calibrate a Quadratic Normal model. We investigate an alternative scheme for the implementation of RMQA based on the Lloyd I method [3] in combination with the Anderson acceleration Algorithm [4, 5] developed to solve fixed-point problems. The accelerated scheme permits to speed up the linear rate of convergence of the Lloyd I and to fix some flaws of previous RMQA implementations highlighted in [2].

The second approach, LTSA, discretises in an appropriate way the infinitesimal Markov generator of the underlying diffusion by means of a finite difference scheme. In [6] LTSA idea is employed to price a particular class of path-dependent payoffs. The RMQA and LTSA present two major differences which can be summarized as follows: (i) the RMQA permits to recover the optimal – according to a specific criterion [7, 8] – multinomial grid, whereas the LTSA works on a a priori user-specified grid, (ii) the LTSA necessitates less computational burden than the RMQA when pricing financial derivatives products whose payoff requires the observation of the underlying on a predefined finite set of dates. Unfortunately, this result holds only for a piecewise time-homogeneous local volatility dynamics.

Then, we present and discuss how our implementation of the Monte Carlo algorithm can be applied to option pricing. In particular, we consider the following types of path-dependent options on FX rates: (i) Asian calls, (ii) up-and-out barrier calls, (iii) automatic callables (or auto-callables). We achieve a sizeable reduction of the variance associated with Monte Carlo estimators. Our conclusion is extensively supported by numerical results.

References

1. Pagès, G., Sagna, A. Recursive marginal quantization of an Euler scheme with applications to local volatility models. *arXiv preprint arXiv:1304.2531*, 2013.
2. Callegaro, G., Fiorin, L., Grasselli, M.: Pricing and calibration in local volatility models via fast quantization. *Risk Magazine*, 2015.
3. Kieffer, J.B.: Exponential rate of convergence for Lloyd's method I. *Information Theory, IEEE Transactions on*, 28(2):205–210, 1982.
4. Anderson, D.G.: Iterative procedures for nonlinear integral equations. *Journal of the ACM (JACM)*, 12(4):547–560, 1965.
5. Walker, H.F. and Ni, P.: Anderson acceleration for fixed-point iterations. *SIAM Journal on Numerical Analysis*, 49(4):1715–1735, 2011.
6. Albanese, C., Lo, H., Mijatović, A.: Spectral methods for volatility derivatives. *Quantitative Finance*, 9(6):663–692, 2009.
7. Pagès, G. and Printems, J.: Optimal quadratic quantization for numerics: the Gaussian case. *Monte Carlo Methods and Applications*, 9(2):135–165, 2003.
8. Pagès, G. and Printems, J.: Functional quantization for numerics with an application to option pricing. *Monte Carlo Methods and Applications mcma*, 11(4):407–446, 2005.

Flash crashes, jumps and running jumps: a new method for jump detection

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J.E.L. classification: C12, C58, G10.

Abstract

With the increased complexity of trading, we aim to identify the number, location and magnitudes of jumps each trading day in a financial series in which jumps are likely to show a clustering, or contagious effect. We try a Realized Volatility and Bi-power Variation (the RV-BV) method, proposed by [3, 4] and [1], on the S&P500 series recorded every two minutes. Surprisingly, we find no indication of jumps having occurred on flash-crash day (06 May, 2010) and other similar days. The fundamental problem of this method is that it cannot tolerate large returns on consecutive intervals, which can cause the bi-power variation to exceed the daily realized volatility, and consequently leads to the conclusion that no jumps have occurred on such a day, even though jumps have clearly occurred.

We therefore propose a new jump detection method based on finding individual 2-minute returns that are large compared to a local volatility measure. We use a median approach to estimate local volatility, a generalization of an idea by [2], to avoid the masking effects that often occur with measures based on mean realized volatility or bi-power variation. We further introduce running jumps' aimed explicitly at studying the occurrence of sequences of large neighbouring returns that effectively form a single jump that evolves over a number of successive intervals.

We test our methods on S&P500 price behavior between 03 January 2006 and 13 March 2015. We find that our method, in comparison to RV-BV method, robustly captures significant jumps and jump runs on the Mini Flash Crash day and other days when there are market events triggering sharp volatility variations. We also compare the performance of our method with that of the RV-BV method on three simulated series.

References

1. Andersen, T. G., Bollerslev, T., Frederiksen, P., Nielsen, M: Continuous time models, realized volatilities and testable distributional assumptions for daily stock returns. *Journal of Applied Econometrics* **25** (2010) 233-261.
2. Andersen, T. G., Dobrev, D., Schaumburg, E.:Jump robust volatility estimation using near neighbour truncation. *Journal of Applied Econometrics* **169** (2012) 75-93.
3. Barndorff-Nielsen, O.E., Shephard, N.: Econometric analysis of realized volatility and its use in estimating stochastic volatility models. *Journal of the Royal Statistical Society Series* **B64** (2002) 253-280.
4. Barndorff-Nielsen, O.E., Shephard, N.: Power and bipower variation with stochastic volatility and jumps *Journal of Financial Econometrics* **2** (2004) 1-37.

Pricing via quantization in local and stochastic volatility models

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J.E.L. classification: C63, G13.

Abstract

Quantization is a widely used tool in information theory, cluster analysis, pattern and speech recognition, numerical integration, data mining and, as in our case, numerical probability. Quantization consists in approximating a signal admitting a continuum of possible values, by a signal that takes values in a discrete set. *Vector quantization* deals with signals that are finite dimensional, such as random variables, while *functional quantization* extends the concepts to the infinite-dimensional setting, as it is the case of stochastic processes. Quantization of random vectors can be considered as a discretization of the probability space, providing in some sense the best approximation to the original distribution.
While theoretically sound and deeply investigated, optimal quantization typically suffers from the numerical burden that the algorithms involve. The main reason is related to the highly time-consuming procedure required by the determination of the optimal grid, especially in the multi-dimensional case where stochastic algorithms are necessary. Recently a very promising type of quantization, called *recursive marginal quantization*, see [5], has been introduced and applied to the Euler scheme of a pseudo-CEV local volatility model in a pricing context. This new approach provides sub-optimal quantization grids in a very precise and fast way.
We find stationary quantizers via a Newton-Raphson method, in order to efficiently price vanilla and exotic derivatives. Indeed, the Newton-Raphson procedure, being deterministic, is very fast and it allows us to provide the first example of calibration based on quantization. The recursive marginal quantization is competitive even when closed form formulas for vanillas are available (as in the case of call and put prices for the Quadratic Normal Volatility model).
In our paper we apply recursive marginal quantization to a special local volatility model, namely the Quadratic Normal Volatility model, developed by [1], and to many stochastic volatility models, like the Stein Stein model in [4], the SABR model introduced in [7], and the recent α-hypergeometric model develeped by [6].

We propose the first calibration exercise based on quantization methods for the local volatility model. Pricing and calibration are typically difficult tasks to accomplish: pricing should be fast and accurate, otherwise calibration cannot be efficiently performed. A successful calibration of the Quadratic Normal Volatility model is performed in order to show the potentiality of the method in a concrete example, while a numerical exercise on pricing of barrier options shows that quantization over performs Monte Carlo methods.
We will then apply the recursive marginal quantization method also to the stochastic volatility models and we will compare prices of vanillas with the corresponding benchmark prices. Moreover, we will see that the quantization based approach can also be applied to the pricing of non-vanilla options. In order to give an idea of the flexibility of our approach, we consider a particular class of exotics, namely equity volatility options, that are receiving a growing attention in the financial community. Pricing of equity volatility options represents a challenging topic, especially for non affine models, for which Monte Carlo represents the only alternative. We are going to show that the quantization based algorithm is much more performing than the standard Monte Carlo approach.

References

1. Andersen, L.: Option Pricing with Quadratic Volatility: a Revisit. Available at SSRN: http://ssrn.com/abstract=1118399 (2008).
2. Graf, S., Luschgy, H.: *Foundations of quantization for probability distributions*, Springer-Verlag New York, Inc. (2000).
3. Pagès, G., Pham, H., Printems, J.: Optimal quantization methods and applications to numerical problem in finance. In: Rachev, S.T. (ed.) *Handbook of Computational and Numerical Methods in Finance*, Birkhfauser, Boston (2003).
4. Stein, E. M., Stein, J. C.: Stock price distributions with stochastic volatility: an analytic approach. *Review of Financial Studies* **4** (1991) 727-752.
5. Pagès, G., Sagna, A.: Recursive marginal quantization of the Euler scheme of a diffusion process. Preprint available at: http://arxiv.org/abs/1304.2531 (2014).
6. Da Fonseca, J., Martini, C.: The α-Hypergeometric Stochastic Volatility Model. (2014). Working Paper, available at http://ssrn.com/abstract=2497696.
7. Hagan, Patrick s., D.K.A.S. L., Woodward, D. E.: Managing smile risk. *Wilmott magazine* September (2002) 84-108.

Evaluation systems: being or not being additive?*

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Abstract

Nowadays, the evaluation of activities like health care programs, university research and similar is increasingly widespread. According to a pervasive belief, the goodness of the evaluation mainly depends on the use of indicators which are strongly representative of the activities to evaluate. For instance, the proportion of specialist to other doctors in the case of health care programs, and the number of citations of a publication in the case of university research. At the same time, it is substantially neglected that such indicators are used after their processing through more or less complex metrics. Therefore, the goodness of the evaluation mainly depends on the assumptions underlying the construction of the metrics. In this contribution we intend to discuss the implications of the absence/presence of the additive property within the assumptions on which are based many evaluation systems. In particular, our analysis is articulated in three points.

In the first point we critically review the main literature on evaluation systems satisfying or not the additive property and we show some counterintuitive results coming from the use of these evaluation systems. We refer in particular to [?], [?], and [?] in which a general evaluation model for bibliometric rankings analyzed from an axiomatic point of view.

In the second point we discuss the properties of different evaluation methods such as the number of papers, the number of highly cited papers, the h-index, the maximum number of citations and so on. It is worth noting that each bibliometric indicators is able to highlights a particular dimension of research output, while suffering of some drawbacks. Actually the choice of which indicators has to be used depends on the aims of the evaluation process, for instance hiring or funding decisions, internal or external assessment.

In the third point we intend to apply the different evaluation system considered before to some real data extracted from a database of university researchers.

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References

1. Bouyssou, D., Marchant, T.: An axiomatic approach to bibliometric rankings and indices. *Journal of Infometrics* **8** (2014) 449-477.
2. Marchant, T.: An axiomatic characterization of the ranking based on the h-index and some other bibliometric rankings of authors *Scientometrics* **80** (2009) 327-344.
3. Cardin, M., Corazza, M., Funari, S., Giove, S.: A fuzzy-based scoring rule for author ranking: An alternative to h-index. In: Apolloni, B., Bassis, S., Morabito, C.F. (eds.): *Frontiers in Artificial Intelligence and Applications*, Vol. 234, IOS Press, Amsterdam (2011) 36-45.

Dynamic Adaptive Mixture Models with applications

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J.E.L. classification: C51, C53, C58.

Abstract

Mixtures of distributions are extremely diffused parametric tools used to model non Gaussian shapes that usually characterise empirical data. Within the context of Mixture Models (MM), the mixture composition as well as the mixture components can be allowed to evolve over time, this class of models is usually identified as Dynamic Mixture Models (DMM), and have been developed and applied in process monitoring [6], intervention detections [4], insurance losses [3] and other relevant scientific fields of research. DMM are usually estimated relying on computer intensive Markov Chain Monte Carlo (MCMC) simulation schemes to carry out Bayesian inference which highly reduce the attractiveness of such models and their implementation in commercial softwares, see e.g. [4], [6] and [1]. In this paper we follow a different approach to model the time evolution of the mixture component distributions as well as the mixture compositions in a fully observation driven framework exploiting recent advantages in Score Driven models, see e.g. [5] and [2]. We allow for the mixture composition and the mixture components to be sequentially updated using the information contained in data. We call this class of models Dynamic Adaptive Mixture Models (DAMM) given their high flexibility in terms of possible dynamic parametric assumption and their ability to sequentially adapt the mixture composition. A Monte Carlo experiment reveals that DAMMs are able to adequately approximate the first two conditional moments as well as the dynamic mixture composition generated by the Stochastic DMM (SDMM). To further investigate the properties of the proposed DAMM we also report an empirical application in time series econometrics. Specifically, we apply the DAMM to the percentage changes of the US Consumer Price Index (CPI). We found that the DAMM with two Gaussian components outperforms several alternative specifications usually employed to forecast CPI changes. Formally, the DAMM formulation is detailed below.

Let $\mathbf{y}_t \in \Re^d$ be a d–dimensional random vector conditionally distributed according to $p\left(\mathbf{y}_t|\mathcal{F}_{t-1}, \boldsymbol{\theta}_t\right)$, with $\mathcal{F}_{t-1}$ be the filtration generated by the process $\{\mathbf{y}_s, s > 0\}$ up to time $t-1$, and $\boldsymbol{\theta}_t$ be a vector of time varying conditional parameters. We will assume $p\left(\cdot\right)$ to be a finite mixture of J real valued conditional distributions, i.e.

$$p\left(\mathbf{y}_t|\mathcal{F}_{t-1}, \boldsymbol{\theta}_t\right) = \sum_{j=1}^{J} \omega_{j,t} p_j\left(\mathbf{y}_t|\mathcal{F}_{t-1}, \boldsymbol{\theta}_{j,t}\right), \tag{1}$$

with $\omega_{j,t} \in (0,1)$ and $\sum_{j=1}^{J} \omega_{j,t} = 1 \quad \forall \quad t = 1,\ldots$ and $\boldsymbol{\theta}_t = \left(\boldsymbol{\theta}'_{j,t}, \omega_{j,t}, j = 1,\ldots,J\right)'$. Let $\boldsymbol{\omega}_t = (\omega_{j,t}, j = 1,\ldots,J)$ be the vector containing the mixture weights at time t, and $\tilde{\boldsymbol{\omega}}_t \in \Re^{J-1}$ be a $(J-1)$–dimension vector such that $\Lambda^{\omega}(\tilde{\boldsymbol{\omega}}_t) = \boldsymbol{\omega}_t$, for a deterministic time independent twice differentiable function $\Lambda^{\omega} : \Re^{J-1} \rightarrow \mathcal{S}^J$ with $\mathcal{S}^J$ representing the standard unit J–simplex, i.e. $\mathcal{S}^J : \{(t_1,\ldots,t_{J+1}) \in \Re^{J+1} | \sum_{j=1}^{J+1} t_j = 1 \wedge t_j \geq 0, \quad \forall j\}$. Similarly, let $\tilde{\boldsymbol{\theta}}_{j,t}$ be a d_j–dimension vector such that, for each time t, we have $\Lambda^j\left(\tilde{\boldsymbol{\theta}}_{j,t}\right) = \boldsymbol{\theta}_{j,t}$ where $\Lambda^j : \Re^{d_j} \rightarrow \Omega_j$ holds the same properties stated for $\Lambda^{\omega}(\cdot)$ for all $j = 1,\ldots,J$. In order to avoid complicated nonlinear constraints on the parameters dynamic, in this paper, instead of directly modeling the quantity of interest $\boldsymbol{\theta}_t$ defined on $\mathcal{S}^J \times \Omega^1 \times \cdots \times \Omega^J$, we model the unconstraint vector of parameters $\tilde{\boldsymbol{\theta}}_t = \left(\tilde{\boldsymbol{\omega}}'_t, \tilde{\boldsymbol{\theta}}'_j, j = 1,\ldots,J\right)'$ defined on $\Re^{J-1} \times \Re^{d_1} \times \cdots \times \Re^{d_J}$. To this end, we reparametrise the conditional distribution (1) into $\tilde{p}\left(\mathbf{y}_t|,\tilde{\boldsymbol{\theta}}_t\right)$, defining the "full mapping function" $\Lambda : \Re^{J-1} \times \Re^{d_1} \times \cdots \times \Re^{d_J} \rightarrow \mathcal{S}^J \times \Omega^1 \times \cdots \times \Omega^J$ that incorporates $\Lambda^{\omega}(\cdot)$ and $\Lambda^j(\cdot), \quad j = 1,\ldots,J$, such that $\Lambda\left(\tilde{\boldsymbol{\theta}}_t\right) = \boldsymbol{\theta}_t, \quad \forall t$. In the Score Driven Framework, the quantity of interest is the score of the conditional distribution given by

$$\tilde{\nabla}\left(\tilde{\boldsymbol{\theta}}_t|\mathbf{y}_t\right) = \left.\frac{\partial \ln \tilde{p}\left(\mathbf{y}_t|\tilde{\boldsymbol{\theta}}\right)}{\partial \tilde{\boldsymbol{\theta}}}\right|_{\tilde{\boldsymbol{\theta}}=\tilde{\boldsymbol{\theta}}_t} = \left[\left(\frac{\mathbf{d}\Lambda}{\mathbf{d}\tilde{\boldsymbol{\theta}}}\right)' \frac{\partial \ln p\left(\mathbf{y}_t|\boldsymbol{\theta}_t\right)}{\partial \boldsymbol{\theta}}\right]\Bigg|_{\tilde{\boldsymbol{\theta}}=\tilde{\boldsymbol{\theta}}_t}$$

which enters linearly as a forcing variable into the dynamic updating equation of $\tilde{\boldsymbol{\theta}}_t$, i.e.

$$\tilde{\boldsymbol{\theta}}_{t+1} = \boldsymbol{\kappa} + \mathbf{A}\tilde{\nabla}\left(\tilde{\boldsymbol{\theta}}_t|\mathbf{y}_t\right) + \mathbf{B}\tilde{\boldsymbol{\theta}}_t,$$

where $\boldsymbol{\kappa}$ is a $\left(J - 1 + \sum_{j=1}^{J} d_j\right) = L$–dimension vector and $\mathbf{A}$ and $\mathbf{B}$ are $L \times L$ matrices of coefficients that can be estimated by Maximum Likelihood.

References

1. Billio, M., Casarin, R., Ravazzolo, F., and Van Dijk, H. K. (2013). Time-varying combinations of predictive densities using nonlinear filtering. *Journal of Econometrics*, 177(2):213–232.
2. Creal, D., Koopman, S. J., and Lucas, A. (2013). Generalized autoregressive score models with applications. *Journal of Applied Econometrics*, 28(5):777–795.
3. Frigessi, A., Haug, O., and Rue, H. (2002). A dynamic mixture model for unsupervised tail estimation without threshold selection. *Extremes*, 5(3):219–235.
4. Gerlach, R., Carter, C., and Kohn, R. (2000). Efficient bayesian inference for dynamic mixture models. *Journal of the American Statistical Association*, 95(451):819–828.
5. Harvey, A. C. (2013). *Dynamic Models for Volatility and Heavy Tails: With Applications to Financial and Economic Time Series.* Cambridge University Press.
6. Yu, J. (2012). A particle filter driven dynamic gaussian mixture model approach for complex process monitoring and fault diagnosis. *Journal of Process Control*, 22(4):778–788.

The role of financial literacy and financial education in the diversification strategies

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J.E.L. classification: C15, C53, C58.

Abstract

The risk-taking behaviour as well as diversification strategies followed by a non-professional investor are influenced by its financial literacy and by its financial education that we consider as different constructs. The studies on financial literacy [1], [2] show that exists a positive relationship with financial behaviour whereas the relation between financial education and financial behaviour is less clear.

In this paper we investigate the role played by financial education and by financial literacy of non-professional investors in the risk-taking decision process as well as in the portfolio selection strategies they pursue. More precisely on the one hand we hypothesised that financial education affects both the diversification strategy of the investors and the financial literacy, on the other hand we study if the financial literacy exert its influence on the diversification strategy. In this second case we consider that financial literacy could play the the role of mediator variable.

The main variables that we study in this paper are latent variables that we can measure by mean of several observable variables. With this aim we designed a questionnaire that was devided into three parts. The first part collected information about how the individuals take risks and define diversification strategies (three items measured by a constant sum scale); the second one, measured the respondent's level of financial literacy (five items); finally, the last part collected personal information (seven items).

The questionnaire was submitted via web using Amazon Mechanical Turk and we collected 711 questionnaires of US residents. With the aim to test the hypotheses and considering that we have to deal with latent variables we estimate a Partial Least Squares Path Modeling. This model is, in our case, very usefull since allows us to test simultaneously the relationship between the latent variables i.e. financial literacy, financial education and risk-taking.

The results of our analysis show that financial education and financial literacy impact on the investment process of investors. Moreover financial literacy play

also a role of moderator variable in the relation between financial education and investment process of investors. These results have important implications showing that financial education can trigger relevant changes in the investment patterns of investors.

References

1. Christelis D., Jappelli T., Padula M., Cognitive abilities and portfolio choice, *European Economic Review*, vol. 54(1), pp. 18-38, (2010),
2. Van Rooij, M., Lusardi, A., Alessie, R., Financial literacy and stock market participation, *Journal of Financial Economics*, vol. 101(2), pp. 449-472, (2011).

Robust decentralized investment games

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J.E.L. classification: C44, C61, C72, D86.

Abstract

Assuming a one-period economy with an investor and two portfolio managers who are experts in investing each in a risky asset (or an index) with first and second moment information available to all parties, we consider the problem of the principal in distributing her wealth optimally among the two managers as well as setting optimally the fees to the portfolio managers under the condition that the principal wants to safeguard against uncertainty in the expert forecasts of the managers regarding the mean return of assets. A typical application is the problem of a Centralized Investor (e.g. the Head of a Pension Fund) who has to allocate a capital W_0 between two managers. The managers have an exponential utility with parameter β_i and are remunerated through an affine contract based on the wealth obtained from their trading activity. The managers' knowledge of the market is modeled by a private signal, see e.g., [1] for related previous work.

In the basic problem the market consists of two risky assets with rate of return X that is bi-variate normal $N(\bar{X}, \Sigma)$ and one riskless asset with rate of return r. Let us denote the variance of the return of asset i by σ_i^2.

The principal allocates a portion $0 < \alpha < 1$ of his wealth to the first manager and $1 - \alpha$ to the second manager. In case 1 each manager invest in only one of the two risky assets, that is manager 1 is restricted to invest in asset 1, manager 2 in asset 2. In case 2 both managers invest in both risky assets.

Manager i receive a private signal

$$S_i = X_i + \epsilon^i,$$

where ϵ^i is normally distributed with zero mean and standard deviation $\sigma_{\epsilon,i}$, a scalar representing the manager's expertise.

We investigate, both theoretically and numerically, the two cases using a max-min approach for the principal who wishes to make a robust allocation of wealth against uncertainties in the expertise of the managers. The uncertainty representation is chosen as ellipsoidal uncertainty since we are following the growing literature on robust optimization [2].

Among other things, our results show, for example, that with his/her increasing disbelief in the expertise announced by managers, the principal begins to allocate much less to a manager commanding the more profitable but riskier

asset but who is more reliable in forecasts, but rewards slightly more lucrative contract to that manager, while a a bigger chunk of the budget but a less attractive contract to the second manager commanding the less profitable but less risky asset.

Our results revealed that there are two major problems pertaining to allocation of the principal's wealth to the managers, and unfairness of contracts rewarded to them. The problem arises since the manager's knowledge of the market is a private information and therefore there is no direct way to know their true risk aversion levels. If we do not assume that they will reveal their true risk aversion levels then one manager can exploit this by being less risk averse and hence obtaining more lucrative contract. The situation gets worse if the other manager also decides to lower his risk aversion level which leads to a race between managers and greatly distorts the outcomes and results in a way that contradicts the principle's aim of adopting a worst-case max-min approach. There is still a problem even if we assume that the managers announce their true risk aversion levels, e.g, if one manager is more risk averse and the other manager is less risk averse, then the first manager will be rewarded by a much less attractive contract, on the other hand the second manager will be rewarded by a more lucrative contract that may not reflect their true efforts. This results in unfair contracts rewarded to the managers, and violates an envy-free division. To remedy these undesired outcomes, we introduce two new approaches to determine their contracts. In the first one,we assume the original problem's setup. Given the risk aversion levels, by introducing a mini game between managers, we can induce more balanced capital allocation between managers, and at the same time the contracts rewarded to managers will be envy-free. In the second one, again by introducing another mini game between managers, but this time, played before they reveal their risk aversion levels without assuming that they will reveal the true one, we investigate the outcome. This way, we can ensure a fair environment for managers with envy-freeness of their contracts as well as a balanced capital allocation between them which also benefits the principal.

The results will be presented and discussed.

References

1. Fabretti, A., Herzel, S.: Delegated Portfolio Management with Socially Responsible Investment Constraints. *The European Journal of Finance* **3-4** (2012) 293-309.
2. Ben-Tal, A., El Ghaoui, L., Nemirovski, A.: *Robust Optimization.* Princeton University Press (2009).

An analysis on the Premium Risk for the Italian market

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J.E.L. classification: C02, G22.

Abstract

Solvency 2 directive provides a range of methods to calculate the Solvency Capital Requirement (SCR), which allows companies to choose a method that is proportionate to the nature, scale and complexity of the risk that is measured. Focusing on the Standard Formula (SF) approach the Delegated Acts (see [3]) describes a subset of the SF market parameters (standard deviations), in order to calculate the SCR deriving from Premium Risk: the risk that can arise from fluctuations in the timing, frequency and severity of insured events. It includes the risk that premium provisions might turn out to be insufficient to compensate claims or need to be increased and the volatility of expense payments.

Following the publications listed below ([1],[2] and [4]), this paper is a joint work with ANIA (National Association of the Insurance Companies) and Towers Watson (TW) with the aim of producing an analysis on Premium Risk for the Italian Market. In particular, a Partial Internal Risk Model (PIRM) has been developed using Generalised Linear Model (GLM, see [5] for more details) in order to calculate a standard deviation of Premium Risk that can replace the market volatility of the SF.

The PIRM developed in this paper stress the value of the techniques already used in the pricing process to estimate the frequency, severity and consequently the premium of an insurance product. This PIRM could be useful for the future Actuarial Function and/or the Risk Management as well. GLM, benchmark within this technical framework, is the model used to calculate the expected value and the total distribution of the Aggregate Ultimate Claim Amount in a one-year horizon (ACA). If the expected value is the result needed for a pricing purpose, the distribution of the ACA allows to calculate the SCR for Premium

Risk under Solvency 2. Results are influenced also by a detailed evaluation of the business mix (i.e. renewals and new business) expected for the year following the determination of the SCR. Using Motor Third Party Liability insurance data of the private car in the Italian Market, an explorative data analysis will be showed in order to check the probability assumption about the number of claims and claim amount, split between attritional and large losses. Moreover, GLM, calibrated on the observed insured, for attritional and large losses, will be applied on a projected population of insured to take into consideration the evolution on the future business mix (i.e. renewals and new business).
Finally the paper will show a comparison between the SCR results for Premium Risk determined using the SF market parameters and the PIRM.

References

1. ANIA, Towers Watson: Il Premium Risk nei Modelli di Pricing. *Proceedings of ANIA-Towers Watson Congress*, Milan (2015).
2. Cerchiara R.R., Magatti, V.: The Estimation of Standard Deviation of Premium Risk Under Solvency 2. *Mathematical and Statistical Methods for Actuarial Sciences and Finance*, Springer International Publishing (2014) 61-64.
3. European Commission: *Solvency II Delegated Acts*. Brussels (2015).
4. Magatti, V.: *Il Premium Risk nei Modelli di Pricing*. PhD thesis, University La Sapienza, Rome (2015).
5. Nelder, J.A., Wedderburn, R.W.M.: Generalized Linear Models. *Journal of the Royal Statistical Society, Series A* **135** (1972) 370-384.

A network approach for risk theory and portfolio selection

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J.E.L. classification: D81, D85, G11.

Abstract

In the context of portfolio theory, the evaluation of risk is of paramount relevance. In this respect, the connections between the risky assets of the portfolio should be carefully explored.

This paper elaborates on this topic. We define a portfolio through a network, whose nodes are the assets composing it. The weights on the nodes and the arcs represent the share of capital invested on the assets and the dependence among them, respectively. We conceptualize the algebraic structure of the set of portfolios in this specific setting, in order to develop the related financial theory. The risk profile of the portfolio will be given through a suitably defined risk measure on the portfolio-network.

The standard Markowitz theory will be rewritten in this particular setting. Surprisingly, we will note that the resulting decision problem is not consistent with an adapted version of the axiomatization of the standard expected utility theory. With this aim in mind, we propose an original reformulation of some of the standard von Neumann-Morgenstern axioms in the language of networks. As a scientific ground, we advance the proposal that the weights of the arcs and of the nodes play an active role in the statement of the axiomatization of the preference order. It is also shown that the new axiomatization represents a concrete extension of the standard expected utility axioms. In accordance with existing literature, we obtain that a risk evaluation problem can be meaningful even if it is not consistent with the standard axiomatization of expected utility theory. To the benefit of the reader, we also provide some illustrative examples, which address the theoretical concepts presented in the paper.

References

1. Abrahamsen, E.B., Aven, T.: On the consistency of risk acceptance criteria with normative theories for decision-making. *Reliability Engineering & System Safety* **93(12)** (2008) 1906-1910.

2. Aven, T., Vinnem, J.E.: On the use of risk acceptance criteria in the offshore oil and gas industry. *Reliability Engineering & System Safety* **90(1)** (2005) 15-24.
3. Cerqueti, R., Lupi, C.: Consistent Risk Acceptance Criteria through Networks. *Economics & Statistics Discussion Papers* **esdp15076** University of Molise, Dept. EGSeI (2015).
4. Chateauneuf, A., Eichberger, J., Grant, S.: Choice under uncertainty with the best and worst in mind: Neo-additive capacities. *Journal of Economic Theory* **137(1)** (2007) 538-567.
5. Chew, S. H., Epstein, L., Wakker, P.: A unifying approach to axiomatic non-expected utility theories: Correction and comment. *Journal of Economic Theory* **59(1)** (1993) 183-188.
6. Chew, S. H., Epstein, L.G.: A unifying approach to axiomatic nonexpected utility theories. *Journal of Economic Theory* **49(2)** (1989) 207-240.
7. Geiger, G.: On the statistical foundations of non-linear utility theory: The case of status quo-dependent preferences. *European Journal of Operational Research* **136(2)** (2002) 449-465.
8. von Neumann, J., Morgenstern, O.: *Theory of Games and Economic Behavior*. Princeton University Press, Princeton, NJ (1944).

Modelling hypotheses, policy advice and regulation: a probabilistic argument

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J.E.L. classification: A130, B410, P000.

Abstract

The central assumption of modern finance is the no-arbitrage condition (see [3]), which derives from the Efficient Market Hypothesis ([5], [6]). The no-arbitrage condition is the logical equivalent of the no-profit condition under Competitive General Equilibrium (CGE, [4] or [1]). The latter is retained by most of public choice. CGE implies market efficiency and thus self-regulated markets. Given recent market coordination and regulation failures, the question is whether CGE assumptions (and therefore modern finance and public choice) "map" a sufficiently large range of possible real economic outcomes.

Referring to [9] the first part of the paper illustrates the *negligibility* of the CGE assumptions by quantifying their probability. Simple but prudently realistic applications of the principle of composed probability and of the related Bayes theorem illustrate that CGE assumptions are rather implausible, with a joint probability estimated below 10%.

The second part examines *heuristic aspects*. This is done by grouping logically alternative assumptions into a hierarchical tree. 32 hypotheses are grouped in 10 levels, covering a rather large portion of economic theory. There is no claim that the analysis is exhaustive: other issues could be added in a different order. However, the detail is sufficiently realistic. For instance, if one retains at the first level three possible alternatives concerning risk (no risk, risk and uncertainty), and combines them at the immediately lower level with 5 possible assumptions concerning time (stationary time, steady state, temporary equilibrium, traverse and path dependency), one obtains 15 branches. If there are n groups of hypotheses (or levels), each covering m_i assumptions ($i = 1, \dots, n$), the total number of possible combinations at the nth level, is given by the product of the number of assumptions considered for each node: $m_1 * m_2 * \dots * m_n$. An example is developed for a tree with 10 levels where the number of possible combinations is shown to be 64,800 (the 10 levels are respectively the root and the assumptions on risk; dynamics; number of goods; number of sectors; money; consumption; production; space; distribution and technology). Heuristic aspects are addressed by contrasting the group of hypothesis ordinarily retained under the "mainstream view" with those followed by competing paradigms. First out of the 64,800 branches one takes out those chains of assumptions not covered

by CGE. If one eliminates at each stage no more than 50% of the assumptions, combining all the levels together one remains with a limited number of the possible cases covered by CGE: in the example developed: 16% at level 5 and less than 1% at level 10. Radial charts are drawn for the resulting trees. They illustrate graphically the domain of relevance of groups of assumptions. If, for an agnostic adviser, all combinations are equally probable ex ante at the level 10, the assumptions commonly retained in public choice and in most of finance applications correspond to less than 1% of the possible cases. Let's assume that an alternative approach (labelled Post-Keynesian or PK) requires to drop only one of the assumptions in each of the levels: 3 (number of goods), 8 (space) and 10 (technology). Then this theory would cover 22% of the possible cases. Alternatively, if PK assumptions to be dropped are the same as CGE, except for the first two levels (risk and time), for which one retains all 15 alternatives for PK, then PK covers 2.2% of the possible cases, i.e. 2.5 times more than CGE.

Pluralistic policy advice should thus be based on a preliminary comparison of different possible theoretical models and a discussion of the relevance of their assumptions for the reality in which policy based on this advice is supposed to produce its effects [7].

References

1. Black, F. (2010). *Exploring General Equilibrium.* MIT Press, Cambridge MA.
2. de Finetti, B. (2008 [1979]). *Bayes theorem,* Ch. 4 in *Philosophical Lectures on Probability collected, edited, and annotated by Alberto Mura,* pp. 31-45. Springer Science + Business Media, New York.
3. Demange, G. and Laroque, G. (2001). *Finance et Economie de l'Incertain.* Economica, Paris.
4. Duffie, D. (2001). *Dynamic Asset Pricing Theory.* Princeton University Press, Princeton.
5. Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *The Journal of Finance*, 25(2, Papers and Proceedings of the Twenty-Eighth Annual Meeting of the American Finance Association New York, N.Y. December, 28-30, May 1969):383–417.
6. Fama, E. F. (1991). Efficient capital markets: Ii. *The Journal of Finance*, 46(5, December):1575–1617.
7. Roncaglia, A. and Tonveronachi, M. (2014). Post-keynesian, post-sraffian economics: An outline. In Papadimitriou, D., editor, *Contributions to Economic Theory, Policy, Development and Finance. Essays in Honour of Jan A. Kregel*, pages 40–64. Palgrave Macmillan, New York.
8. Papadimitriou, D. (2014) (Ed.). *Contributions to Economic Theory, Policy, Development and Finance. Essays in Honour of Jan A. Kregel.* Palgrave Macmillan, New York.
9. Salanti, A. (1985). Le assunzioni della teoria economica: un'ipotesi interpretativa. *Note Economiche*, 1(2):64–88.

Statistical properties of the Seasonal FISSAR model

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J.E.L. classification: C02, C21, C51.

Abstract

In this paper we introduce a new model called Fractionally Integrated Separable Spatial Autoregressive processes with Seasonality for two-dimensional spatial data and denoted Seasonal FISSAR. Spatial models are currently investigated in many research fields like meteorology, oceanography, agronomy, geology, epidemiology, image processing or econometrics ([3], [4]). We focus on the class of separable spatial models.

The studies of spatial data have often shown presence of long-range correlation structures. To deal with this specific feature Boissy et al. (2005) [3] had extended the long memory concept from times series to the spatial context and introduced the class of fractional spatial autoregressive model. Shitan (2008) [6] used independently this model called FISSAR to approximate the dynamics of spatial data when the autocorrelation function decays slowly with a long memory effect. Thus, it seems natural to incorporate Seasonal patterns into the FISSAR model as soon as we work with data collected during many periods or cycles.

We define a sequence of Seasonal FISSAR process by:

$$\begin{aligned}&(1-\phi_{10}B_1)(1-\phi_{01}B_2)(1-\psi_{10}B_1^{s_1})(1-\psi_{01}B_2^{s_2})\\&\times(1-B_1)^{d_1}(1-B_1^{s_1})^{D_1}(1-B_2)^{d_2}(1-B_2^{s_2})^{D_2}X_{ij}=\varepsilon_{ij}\end{aligned}\tag{1}$$

where the integers s_1 and s_2 are respectively the seasonal periods in the ith and j^{th} directions, ϕ_{10}, ϕ_{01},ψ_{10}, ψ_{01} are real numbers and $\{\varepsilon_{ij}\}_{i,j\in\mathbb{Z}_+}$ is a spatial white noise process, mean zero and variance σ_ε^2. The backward shift operators B_1 and B_2 are such that $B_1X_{ij}=X_{i-1,j}$ and $B_2X_{ij}=X_{i,j-1}$. The long memory parameters are denoted d_1 and D_1 for the direction i and for the direction j they are denoted d_2 and D_2.

This new modelling is characterized by four operators: two characterizing the short memory behaviour, $(1-B_1^{s_1})^{D_1}$ and $(1-B_2^{s_2})^{D_2}$ and two characterizing

the long memory behaviour, $(1-\psi_{10}B_1^{s_1})$ and $(1-\psi_{01}B_2^{s_2})$. They take into account the existence of seasonals in two directions. This model will be able to take into account periodic and cyclical behaviours presented in a lot of applications including the modelling of temperatures, agricultural data, epidemiology when the data are collected during different seasons at different locations and also financial data to take into account the specific systemic risk observed on the global market ([1], [5]).

The Seasonal FISSAR modelling has a lot of applications in different fields. To take into account at the same time existence of short memory behaviour and long memory behaviour in time and space permits a greater flexibility for the use of these modellings. It is the objective of this paper which introduces and investigates the statistical properties of a new class of model called Fractionally Integrated Separable Spatial Autoregressive processes with Seasonality. The stationary conditions, an explicit expression form of the autocovariance function and spectral density function have also been given. On another hand, a practical formula of the autocovariance function as a product of covariance for the Seasonal FISSAR process is given. Many of the results given here are natural extensions in two-dimensional of those given in time series context in [2]. Some methods for estimating the parameters of the Seasonal FISSAR model is also discussed in this work.

References

1. Benirschka, M., Binkley J.K.: Land Price Volatility in a Geographically Dispersed Market. *American Journal of Agricultural Economics* **76(2)** (1994) 185-195.
2. Bisognin C., Lopes, S.: Properties of seasonal long memory processes. *Mathematical and Computer Modelling* **49** (2009) 1837-1851.
3. Boissy, Y., Bhattacharyya, B.B., Li, X., Richardson, G.D.: Parameter Estimates for Fractional Autoregressive Spatial Processes. *The Annals of Statistics* (2005) 2553-2567.
4. Gaëtan, C., Guyon, X.: *Modélisation et statistique spatiale.* Springer (2008).
5. Jaworski, P., Piterab, M.: On spatial contagion and multivariate GARCH models. *Applied Stochastic Models Business and Industry* **30** (2014) 303-327.
6. Shitan, M.: Fractionnaly Intergrated Separable Spatial Autoregressive (FISSAR) Model and Some of Its Properties. *Communications in Statistics - Theory and Methods* (2008) 1266-1273.

Term structure of hedging premia and optimal trading strategies in synthetic-cash credit market

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J.E.L. classification: G11, G13.

Abstract

The burst of the financial crisis in Europe evidenced several shortcomings in the synthetic credit market, which were considered to favour distress transmission to the underlying sovereign bonds, especially in peripheral countries.

A joint analysis of synthetic-cash sovereign credit market demands for a joint modeling framework where to price both credit derivatives and underlyings bonds, so that market efficiency can be monitored through hedging portfolios.

Particularly, as default risk arose in the Eurozone, *survival discount factors* must be included in the pricing equations of government securities so as to properly match their market prices. The risk-neutral survival discount curve is instead commonly inferred through a bootstrap procedure, by inverting the pricing equations of *credit default swaps* (CDS) on a set of standard maturities.

The mismatch among such default probabilites term structures is known as the *CDS-bond basis*: its determinants have been extensively discussed both in the corporate [2] and European sovereign sector [4].

The standardization process which interested CDS in late 2009 changed the derivatives' cash flows, introducing an *upfront* payment, paired with a fixed coupon, that substituted *running* free-entrance contracts.

The first contribution of the paper is to infer the yields of hedged positions on a discrete grid using upfront-traded CDS.

The implied yields concern positions where credit risk is shorted out: a comparison with *naked* yields in an affine framework, see [3], allows for the computation of a term structure of hedging premia in the joint synthetic-cash credit market. These *credit risk premia* are compared to spreads *vis-à-vis* Germany, in order to reveal eventual premia mispricing that this credit metric brought forth [5].

The bootstrap methodology allows also to measure *horizontal* arbitrages which are useful to infer the theoretical fair value of *forward* CDS-hedging.

The basis is then retrieved with an augmented par-equivalent CDS methodology [6] (PECDS), based on the *joint* marking-to-market of new standard derivatives and correspondent underlyings.

The interest in the basis is motivated by the the tendency of this latter to be generally positive, and take negative values in distress times, see [2] and [7]: it is thus a useful metric of countries' macro-financial distress conditions.
A *negative basis package* is a fully financed CDS-hedged position that measures the size of potential arbitrages, since interest rate risk is hedged out.
The analysis of this basis in the presence of additional lending devoted to upfront payments financing is yet another contribution of this paper.
The implied *term structure of the basis* allows also to measure mutual liquidity premia discrepancies across the two markets via term-spreads comparison.
Results demonstrates how upfront CDS reverts the basis to zero fastly than running contracts: CDS standardization enhances the markets in terms of efficiency. The efficiency of combined synthetic-cash credit market was indeed extensively debated during the crisis. The practice of short credit derivatives trading was retained to exacerbate liquidity drains in the underlying bonds markets.
This persuaded the European Parliament to take actions in this sense: naked short selling of bonds and naked CDS-trading were banned from the Eurozone, starting from November 1st, 2012. Such non-standard measures remove also the chances of securing positive basis arbitrages, where short selling is required.
An interesting experiment is thus to compare the profit and losses [1] of fully financed naked CDS and CDS-hedged bonds. This allows to recognize *ex-post* the optimal *in-crisis* trading strategy and evaluate the impact of new regulation on the flows of capital across the two markets.
This paper extends in time the results in [7], by covering the weekly time series of nine European countries from 2010 to first half of 2015: the time stub leaves here enough time to the market to digest new regulation.
The analysis reveals how speculative use of derivatives had been more profitable than negative basis arbitrages. The impact of regulatory statements is evident in the post-ban tightening of the basis, which reverts to zero at a faster rate.

References

1. Bai, J., Collin-Dufresne, P.: The CDS-bond basis. *Working paper*, available at http://ssrn.com/abstract=2024531 (2013).
2. Blanco, R., Brennan, S., Marsh, W.: An empirical analysis of the dynamics between investment grade bonds and CDS. *Journal of Finance* 60 (2005) 2255-2281.
3. Collin-Dufresne, P., Solnik, B.: On the term structure of default premia in the swap and LIBOR markets, *Journal of Finance* 56 (2001) 1095-1115.
4. De Wit, J.: Exploring the CDS-bond basis. *Working paper research of the National Bank of Belgium* 104 (2006).
5. Di Cesare, A., Grande, G., Manna, M., Taboga, M.: Recent Estimates of sovereign risk premia for euro-area countries, *Questioni di Economia e Finanza della Banca d'Italia* 128 (2012).
6. Elizalde, A. , Doctor, S., Saltuk,Y.: *Bond-cds basis handbook*, J.P. Morgan Credit Derivatives Research, New York - London (2009).
7. Fontana, A., Scheicher, M.: An analysis of Euro area soveriegn CDS and their relation with government bonds. *European Central Bank working paper* 1271 (2010).

Backtesting Lambda Value at Risk*

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Abstract

Risk measurement and its backtesting are matter of primary concern to the financial industry. The value at risk (VaR) measure has become the best practice. Despite its popularity, after the recent financial crisis, VaR has been extensively criticized by academics and risk managers. Among these critics, we recall the inability to capture the tail risk and the lack of reactivity to the market fluctuations. Thus, the suggestion of the Basel Committee, in the consultative document [2], is to consider alternative risk measures that can overcome the VaR's weaknesses.

A new risk measure, the Lambda Value at Risk (ΛVaR), has been introduced by a theoretical point of view by [3]. The ΛVaR is a generalization of the VaR at confidence level λ. Specifically, the ΛVaR considers a function Λ instead of a constant confidence level λ, where Λ is a function of the losses. Formally, given a monotone and right continuous function $\Lambda : \mathbb{R} \to (0, 1)$, the ΛVaR associates to its distribution function $F(x) = P(X \leq x)$ the number:

$$\Lambda VaR = -\inf \{x \in \mathbb{R} \mid F(x) > \Lambda(x)\} . \tag{1}$$

This new risk measure appears to be attractive for its potential ability to solve several problems of VaR. First of all, it seems to be flexible enough to discriminate the risk among return distributions with different tail behaviors, by assigning more risk to heavy-tailed return distributions and less in the opposite case. In addition, the ΛVaR may allow a rapid changing of the interval of confidence when the market conditions change. Recently, [4] proposed the first application of the ΛVaR to equity markets. In this study, a first attempt of backtesting has also been performed and compared with the VaR. Their proposal is based on the hypothesis testing framework by [5]. Thus, this test evaluates the accuracy of the ΛVaR model by considering the following null hypothesis: the relative frequency of exceptions over the backtesting time window does not surpass the maximum of the Λ function.

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The objective of this paper is to propose a theoretical framework for the backtesting of the ΛVaR. We propose three backtesting methodologies which exploit different features. The first two tests have the objective to evaluate if the ΛVaR provides an accurate level of coverage. Here, we check if the probability that a violation occurs *ex-post* actually coincides with the one predicted by the model (specifically $\lambda_0 = \Lambda(-\Lambda VaR)$). Both these two tests are based on test statistics where the distribution is obtained by applying results of probability theory. The first test is unilateral and provides better results for usual backtesting time window (i.e 250 observations). The second test is bilateral and provides an asymptotic result. Thus, the second test is more suitable for larger sample of observations. In respect of the hypothesis test proposed in [4], we consider a null hypothesis which better takes into account the shape of the Λ function. In such a way, we can evaluate the advantages introduced by the ΛVaR flexibility better than using a null hypothesis based on the Λ maximum.

We propose a third test that is inspired to the approach used by [1] for the Expected Shortfall backtesting. This test is focused on another aspect: it evaluates if the correct coverage of the risk derives from the fact that the model has been estimated with the correct distribution of the returns. Here, the alternative and null hypothesis change. We propose a test statistic for which the distribution is obtained by simulations. We remark that, for this test, it is necessary to keep memory of the entire predictive distribution of the returns at time t. Storage of information may be the main challenge, however it does not poses any technological challenge.

To sum up, the first kind of tests do not directly question if the model has been estimated by using the correct distribution function of the asset returns, but verify if the Λ function has been correctly estimated and allows an actual coverage of the risk. On the other hand, the third test considers Λ as correct and question the impact of the estimation of the P&L distribution on the coverage capacity of the ΛVaR.

Finally, we conduct an empirical analysis based on the backtesting of the ΛVaR, calibrated using the same dynamic benchmark approach proposed by [4]. The backtesting exercise has been performed along six different time windows throughout all the global financial crisis (2006-2011).

References

1. Acerbi, C., Szekely, B.: Back-testing expected shortfall. *Risk* **27** (2014).
2. Basel Committee on Banking Supervision: Fundamental review of the trading book. Second consultative document. Bank for International Settlements (2013).
3. Frittelli, M., Maggis, M., Peri, I.: Risk Measures on P(R) and Value at Risk with Probability/Loss Function. *Mathematical Finance* **24** (2014) 442-463.
4. Hitaj, A., Peri, I.: Lambda Value at Risk: A New Backtestable Alternative to VaR. preprint (2014).
5. Kupiec, P.:Techniques for Verifying the Accuracy of Risk Measurement Models. *Journal of Derivatives* **3** (1995) 73-84.

Provisions for outstanding claims with distance-based generalized linear models*

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Abstract

We calculate claim reserves from a run-off-triangle using generalized linear models (GLM) and we include risk margins in the context of Solvency II. In previous works ([2] and [5]) we developed the formulas of the prediction error in GLM for the future payments (FP) by calendar years $t = k+1, ..., 2k$:

$$FP_t = \sum_{j=t-k}^{k} \hat{c}_{t-j,\, j}, \tag{1}$$

assuming the logarithmic link and the parametric family of distributions named power family:

$$V(\mu_{ij}) = \mu_{ij}^{\xi}. \tag{2}$$

First, in [2], we obtained the formulas in the particular case of the (overdispersed) Poisson, $\xi = 1$, and the logarithmic link. This GLM gives the same reserve estimations as those of the Chain-Ladder deterministic method (see [9] for a description of the classical technique). Then, in [5], we generalized the formulas of the prediction error for the FP by calendar years (1) when the general power family (2) and the logarithmic link are assumed.

We calculate provisions including risk margins. There are different ways to include risk margins. One possibility is to add to the FP a percentage of its prediction error, and another possibility is to calculate directly the values at risk (VaR) of the predictive distributions of the FP. Finally, we can calculate the present value of these alternative quantities.

Now, we are studying the possibility to use distance-based generalized linear models (DB-GLM) (see [6] for a description of the DB-GLM) to solve the problem of claim reserving in the same way as GLM is used in this context. DB-GLM

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can be fitted by using function `dbglm` of the `dbstats` package for `R` (see [1] for a description of the package and for the usage of the implemeted distance-based functions).

As a first approximation, in [3] and [4] we calculated origin year and total reserves assuming the (overdispersed) Poisson distribution and the link function with DB-GLM. In that case, we generalized the Chain-Ladder deterministic method to a new Chain-Ladder stochastic method of claim reserving. With DB-GLM we obtain this particular case when the l^2 Euclidean metric is used. Additionally, we propose to use bootstrapping pairs with the distance-based model to estimate predictive distributions of reserves.

In ([7]) we obtained the formulas of the prediction error in DB-GLM when using the general parametric family of error distributions (2) and the general parametric family of link functions:

$$\eta_{ij} = g\left(\mu_{ij}\right) = \begin{cases} \mu_{ij}^{\lambda}, \ \lambda \neq 0, \\ \log\left(\mu_{ij}\right), \lambda = 0. \end{cases} \tag{3}$$

In this study we calculate the prediction error associated to the origin years and total reserves, and also to the FP for the different calendar years using DB-GLM in the general cases of the power family (2) and of the family of links (3). We make an application with the well known run-off-triangle of Taylor and Ashe of [8].

References

1. Boj, E., Caballé, A., Delicado, P., Fortiana, J.: *dbstats: distance-based statistics (dbstats).* R package version 1.4 (2014). `http://CRAN.R-project.org/package=dbstats`
2. Boj, E., Costa, T., Espejo, J.: Provisiones técnicas por años de calendario mediante modelo lineal generalizado. Una aplicación con RExcel. *Anales del Instituto de Actuarios Españoles* **20** (2014) 83-116.
3. Boj, E., Costa, T.: Claim reserving with DB-GLM: extending the Chain-Ladder method. Presented in the *International Workshop on Proximity Data, Multivariate Analysis and Classification*, Granada, Spain (2014).
4. Costa, T., Boj, E.: Claim reserving using distance-based generalized linear models. Presented in the *Second Conference of the International Society of NonParametric Statistics, ISNPS2014*, Cádiz, Spain (2014).
5. Boj, E., Costa, T.: Provisions for claims outstanding, incurred but not reported, with generalized linear models: prediction error formulation by calendar years. *Cuadernos de Gestión* (2015) (to appear).
6. Boj, E., Delicado, P., Fortiana, J., Esteve A., Caballé, A.: Global and local distance-based generalized linear models. *TEST* (2015) (to appear).
7. Boj, E., Costa, T., Fortiana, J.: Prediction error in distance-based generalized linear models. Presented in the *Conference of the International Federation of Classification Societies, IFCS2015*, Bologna, Italy (2015).
8. Taylor, G., Ashe, F.R.: Second moments of estimates of outstanding claims. *Journal of Econometrics* **23** (1983) 37-61.
9. van Eeghen, J., Greup, E.K., Nijssen, J.A.: *Loss reserving methods.* Surveys of Actuarial Studies **1**, National Nederlanden (1981).

Valuation, simulation and sensitivities under low and high interest rate regimes

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Abstract

Since the 2007 financial crisis, the levels of interest rates in many countries are from time to time so low and stay at the Zero Lower Bound (ZLB) for extended periods of time, such that the common classical models fail to be functional. So it becomes a concern among academics and practitioners to build term-structure models making possible to reproduce low but non-negative interest rates.

There is a growing literature [1], [2], [3], [4] that develops and treats the ZLB consistent models. Most of these mentioned work pay the attention on the suitability of the introduced model to account for the ZLB framework, by putting the emphasis on macroeconomic and forecasting aspects. Meucci and Loregian [3] seem to be the only authors who especially take into account common practical issues, such as the application on risk management and projection of the distribution of the whole term structure of interest rates to arbitrary horizons. They have introduced an approach (we refer to as MeLo model in the sequel) based on the inverse-call transformation, which maps rates into a *normal* model at high-rate regimes and into a *lognormal* model at low-rate regimes.

Here we provide results related to the ZLB context with the intention to serve the perspective of a financial market practitioner, by reconsidering the MeLo model and focusing only on the particular case where the underlying shadow rate is assumed to follow the 1-factor Vasicek model (1-VM). This last is a famous theoretical and practical reference model for which prices in closed forms are available for zero-coupon bonds (ZCB) and other basic interest rate products. Under the 1-VM, the ZCB price depends essentially on three parameters (speed mean-reversion, long-mean term, volatility) which are naturally well-understood from the dynamic model itself. Using the 1-VM as a model for the shadow rate can be thought as leading to a benchmark model for a ZLB framework, we refer here to as the MeLo-1VM, such that one has to add just one smoothing parameter to those of the associated underlying 1-VM.

Convinced by the attractiveness of the MeLo-1-VM (a model easily understandable with very few parameters and highly connected to the benchmark 1VM), we think that the corresponding practical sides as: 1) ZCB pricing, 2) interest rate projection at future time-horizons and 3) price-sensitivity determination, deserve to be analyzed. To perform such requirements is the challenge we fix in this paper.

As the MeLo model does not lead to a closed form price for the ZCB, Meucci and Loregian [3] suggest a numerical partial differential equation technique to perform the pricing computation. Among our first contribution here, related to the MeLo-1-VM, is to provide approximated prices in closed form for the ZCB, easily to follow and implement which do not require long-time computation in comparison with a fully Monte-Carlo simulation.

In contrast to the general description scheme for the risk management in [3], here we provide details and useful formulas permitting concretely to generate scenarios of interest rates curves at a given point or at discrete future time horizons.

None of the authors working on the ZLB framework mentioned above addresses to the issue of deriving interest rate sensitivities which is a decisive aspect in practical position management. Here we propose formulas for the first, second and third order sensitivities of a ZCB price under the MeLo-1-VM. The first two quantities would be seen as the alternative for the classical Fisher-Weil duration and convexity. These last two notions require the hypothesis of a parallel shift of the interest-rate curve, which is not realistic though allowing us to simplify the understanding and calculations. Under the MeLo-1-VM, the interest-rate risk arises from shocks affecting the underlying shadow rate. A new feature related to the sensitivities we consider is that they account for the time passage, in contrast to any common sensitivities (duration, convexity, delta, gamma, ...). Here we just propose quick closed-form approximations for the ZCB price, which may be too rough in some extreme situations, as can be seen in our numerical illustrations and explorations. More accurate approximations can be derived but at the price of technical complexities we would like to avoid in this paper.

References

1. Christensen J., Rudebusch G. Estimation shadow-rate term structure models with near-zero yields *Federal Reserve Bank of San Francisco* http://www.frbsf.org/economic-research/files/wp2013-07.pdf (2013).
2. Feunou B., Fontaine J., Lundblad C. Tractable Term Structure Models and the Zero Lower Bound *Federal Reserve Bank of San Francisco* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2696274 (2015).
3. Meucci A., Loregian A. Neither 'Normal' nor 'Lognormal': Modeling Interest Rates Across All Regimes *Symmys and Università degli Studi di Milano-Bicocca* http://ssrn.com/abstract=2359117. (2014).
4. Monfort A., Pegoraroy F., Renne J.P., Roussellet G. Staying at Zero with Affine Processes: An Application to Term Structure Modelling. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2617675 (2015).

Compositions of conditional risk measures and solvency capital

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Abstract

We consider in this paper compositions of conditional risk measures in order to obtain time-consistent dynamic risk measures designed to determine the solvency capital of a life insurer selling pension liabilities or a pension fund with a single cash-flow at maturity. The aim is to consider the long-term characteristic of these products.

An important drawback of the classic *static* risk measures (see [2, 7, 6]) is that they do not take into account the *information* desclosed through time. These measures only consider the end-points of the time-period. If we deal with liabilities with a maturity of one year, then these risk measures are adapted as we work with a time-horizon equal to the accounting horizon. Because we consider pension liabilities with long-term horizon, this information could be meaningful in the computation of the solvency capital through time, especially on a yearly bases as it is the case for accounting purposes. That is why we consider *dynamic* risk measures as studied in [1, 4, 6, 9]. The information is modelled by a filtration and this filtration is incorporated in the computation of the capital each year.

We first recall the notion of conditional, dynamic and time-consistent risk measures. We motivate the need of a time-consistent dynamic risk measure through a simple example in a finite probability space. It has been proved that a time-consistent dynamic risk measure is closely linked to a backward iteration scheme (see [3]). We then consider this result which gives us a way to construct time-consistent dynamic risk measures from a backward iteration scheme with a composition of conditional risk measures.

This approach has been considered for the determination of solvency capital of life insurance products in [5, 8]. Nevertheless it appaears that the solvency capital obtained can be very expensive if we do not take care of the confidence level of each conditional VaR and TVaR measures involved in the iteration scheme. In order to overcome this difficulty, we consider iterations of different conditional risk measures with a yearly time-step fitting the accounting point of view. We also build these measures in such a way that they are *coherent* with the Solvency II or Swiss Solvency Test frameworks for a one year horizon, meaning that, for

the last year of the product, the measures we introduce here correspond to the one used in these frameworks.

We finally give an application of these measures with the determination of the solvency capital of a pension liability which offers a fixed guaranteed rate without any intermediate cash-flow. We assume that the company is fully hedged against the mortality and underwriting risks. We also attempt to generalize this approach to a setting with more than one cash-flow.

References

1. Acciaio, B., Penner, I.: Dynamic Risk Measures. In: Di Nunno, G., Øksendal, B. (eds.): *Advanced Mathematical Methods for Finance*, chap. 1, Springer Berlin Heidelberg (2011) 1–34.
2. Artzner, P., Delbaen, F., Eber, J.-M., Heath, D.: Coherent Measures of Risk. *Mathematical Finance* **9**(3) (1999) 203–228.
3. heridito, P., Kupper, M.: Composition of Time-Consistent Dynamic Monetary Risk Measures in Discrete Time. *International Journal of Theoretical and Applied Finance* **14**(1) (2011) 137–162.
4. Detlefsen, K., Scandolo, G.: Conditional and dynamic convex risk measures. *Finance and Stochastics* **9**(3) (2005) 539–561.
5. Devolder, P.: Revised version of: Solvency requirement for a long-term guarantee: risk measures versus probability of ruin. *European Actuarial Journal* **1**(2) (2011) 199–214.
6. Föllmer, H., Schied, A.: *Stochastic Finance: An Introduction in Discrete Time*, 3 edn. De Gruyter Graduate. Walter de Gruyter (2011).
7. Frittelli, M., Rosazza Gianin, E.: Putting order in risk measures. *Journal of Banking & Finance* **26**(7) (2002) 1473–1486.
8. Hardy, M.R., Wirch, J.L.: The Iterated CTE: A Dynamic Risk Measure. *North American Actuarial Journal* **8**(4) (2004) 62–75.
9. Pflug, G.C., Römisch, W.: *Modeling, Measuring and Managing Risk.* World Scientific Publishing Co. Pte. Ltd., Singapore (2007).

Liquidity measures throughout the lifetime of the US Treasury bond[*]

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Abstract

This paper examines the price impact of the different components of liquidity throughout the lifetime of the US Treasury bond. We emphasize that market participants take into account that a bond has a finite life and its liquidity passes through different stages that are well-known by the market. We address several research questions. To what extent do market players consider a liquidity term structure in the decision-making process? Does the liquidity premium depend on the aging of the bond? Do the different liquidity components affect the liquidity premium? We hypothesize that liquidity has a deterministic component that should covary with the bonds age in a regular and predictable manner over time. Thus, we can model current expected liquidity as a function of the bonds age with implications for prices.

We consider a measure based on the trading activity (market share) and several microstructure-based liquidity measures from a critical perspective. In concrete terms, we analyze the proxy proposed by [2], the measure by [1] defined as the price impact of a trade per unit traded, and the price dispersion proposed by [5].

To determine an age-based component, we adjust a function to model the term structure of each considered liquidity/illiquidity proxy during the liquidity life cycle. Following [3], these functions provide smooth values of the expected current liquidity for a specific age and are inspired by forms arising from actuarial research on human mortality (see [4]). Market participants may consider this expected current liquidity level and its potential future values as a key input in investors decision-making process.

We find that the bond-aging process drives the time evolution of a deterministic liquidity component, which makes it possible to estimate a trading activity term structure. However, some results for the microstructure-based liquidity

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proxies are inconsistent with expectations. Even controlling for current market-level and bond-level conditions, the random behavior of these illiquidity proxies is predominant.

Finally, we study the liquidity impact on prices. To compute the liquidity premium from Treasury security prices, we use the differences between the observed yield-to-maturity of a two-year Treasury note and its theoretical yield, as given by an explicit term structure model. The theoretical yield-to-maturity is obtained from discounting the original cash flows of the bond by the corresponding spot rates. These daily estimates of the zero-coupon interest rate term structure are obtained by the methodology of [6] and from our daily GovPx dataset of all the traded Treasury bills, notes and bonds. Our yield spread can be understood as a liquidity premium because it reflects the yield differential with respect to a market-averaged liquid asset.

The findings show that the liquidity premium has a deterministic main age-based component. The ability of microstructure-based liquidity measures to reflect this life cycle and their impact on prices are negligible. There is a stochastic component of the liquidity premiums that depends on the unexpected value of the liquidity proxies and the current market-level and bond-level conditions. The expected market share explains a relevant percentage of the yield spread, even when the age is included as an explanatory variable. The abnormal or unexpected value of three of the liquidity proxies has a statistically significant impact. This result, in addition to the relevant explanatory power improvement of the model after including the control variables for market-wide liquidity levels, shows the role played by the stochastic component of the liquidity premium.

To ensure that the results are robust to alternative sub-samples and alternative specifications of the liquidity proxies, we report the results using two sub-samples (the second period begins in August 1998 with the Russian financial crisis) and including Turnover as a proxy for trading activity and Amivest and Roll microstructure-based illiquidity proxies. The robustness checks show that the results remain similar.

References

1. Amihud, Y.: Illiquidity and stock returns: cross-section and time-series effects. *Journal of Financial Markets* **5** (2002) 31-56.
2. Bao, J., Pan, J., Wang, J.: The illiquidity of corporate bonds. *The Journal of Finance* **46(3)** (2011) 911-946.
3. Daz, A., Merrick, J.J., Navarro, E.: Spanish Treasury bond market liquidity and volatility pre- and post-European Monetary Union. *Journal of Banking & Finance* **30** (2006) 1309-1332.
4. Heligman, L., Pollard, J.H.: The age pattern of mortality. *Journal of the Institute of Actuaries* **107** (1980) 49-80.
5. Jankowitsch, R., Nashikkar, A., Subrahmanyam, M.G.: Price dispersion in OTC markets: a new measure of liquidity. *Journal of Banking & Finance* **35** (2011) 343-357.
6. Svensson, L.E.: Estimating and interpreting forward interest rates: Sweden 1992-1994. *National Bureau of Economic Research (No. w4871)* (1994).

Does CRDIV provide an efficient way to deal with banks' simultaneous defaults?

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J.E.L. classification: C15, G01, G21, G28.

Abstract

The Capital Requirement Directive IV (CRDIV) issues detailed rules on the new global regulatory standards for bank capital adequacy. Among the others it requires all instruments in the additional Tier 1 layer of a credit institution to be written down or converted into Common Equity Tier 1 capital (CET1), as soon as the CET1 falls below 5.125% of risk weighted assets (RWA). The contingent convertible bonds (CoCos) tick all the boxes as they may be written down or converted into equity as soon as the bank gets into a threatening situation.

Whether or not the new framework is making the banking sector more resilient, there is still one issue that regulators have never dealt with. The Basel accord in fact imposes a regulatory minimum capital requirement to each bank to cover unexpected losses depending just on their own risk. Instead if some correlation between banks is taken into account how big is the amount of losses not foreseen by Basel? And in this case the level set in legislation for mandatory writing down (or conversion into equity) can help in absorbing those extra losses?

To answer these questions, the paper models the impact of having a specified correlation structure among banks by analysing a sub-sample of 78 banks considered in the 2014 EBA stress test. We show that the aggregated loss conditional on a systemic crisis is 5% higher when using a correlation structure, thus requiring to hold extra funds to cover further losses. We investigate alternative rules for the allocation of extra funds such as:

- Scenario 1. Extra CET1 is required to cover losses whenever a banks suffers of unexpected losses higher than $CET1 - 5.125\% RWA$;
- Scenario 2. all banks are required to hold extra CET1;
- Scenario 3. only the GSIBs are required to hold extra CET1;
- Scenario 4. a random sample of banks is required to hold extra CET1.

We find out that using the 5.125% threshold to call in for extra funds is more efficient than asking GSIBs or all banks to increase their CET1.

We use a micro simulation portfolio model, referred to SYMBOL [1], to estimate the loss distribution of banks. The model starts by estimating the probabilities of default of a bank obligor as assessed by the banking system regulator, and it generates losses among individual banks via Monte Carlo estimation using balance sheet information. The output is the unexpected loss for each bank.

We introduce in the model a correlation structure among banks calibrated using individual bank performance (time series of ROA) and country specific economic indicators (time series of GDP growth rate). We observe that in case of zero correlation only few banks contribute to the overall losses, while losses are spread across banks under a bank by bank correlation. On the other hand, the default rate per bank is 0.1% on average under a level of capital of 8% of RWA, independently on the correlation, which guarantees the compliance of the model to the Basel framework. If one looks at the distribution of defaults (which depends, indeed, on the correlation), we can see that while zero correlation leads to have a similar number of bank's defaults per simulations, increasing correlation the distribution of defaults in each simulation is skewed and affected by extreme events in the tail, reflecting the Basel limitation of considering bank as individual entities and not correlated each others.

We start by estimating losses conditional on a systemic crisis similar to the one of 2008 whose loss was around 1% of EU total assets, according to the amount of state aid provided to the financial sector during 2008-2012 period. Hence, by using extra capital, we align the systemic conditional loss coming from the correlation matrix, with the one foreseen under the Basel framework where correlation among banks is zero.

Scenario 1 identifies a similar set of *problematic* banks as the 2014 EBA stress test and requires these banks to hold around 1% of RWA as extra CET1. The rule set in Scenario 1 for allocating extra capital among banks seems to be efficient in reducing losses in the systemic crisis event. On contrary, rules used in other Scenarios do not detect problematic banks and to make matter worst, they have an huge impact specially on those banks which are already safe enough without any intervention from the regulator.

Finally, we compute the systemic losses conditional on different crisis levels and we estimate the reductions obtained in the four Scenarios, and we show that reduction under Scenario 1 is the highest.

This provides evidence that the CRDIV rule for more capital may help in dealing with the missing piece in the Basel framework.

References

1. De Lisa R., Zedda S., Vallascas F., Campolongo F., and Marchesi M.: Modelling Deposit Insurance Scheme Losses in a Basel 2 Framework *Journal of Financial Services Research* **40(3)** (2011) 123-141.

Profitability vs. attractiveness within a performance analysis of a life annuity business

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J.E.L. classification: C53, G22, G32.

Abstract

The life insurance business is moving towards contractual models increasingly tailor-made, paying attention to both the contracting party's characteristics and the dynamics of the financial and the demographic contexts in which the inflows and the outflows are going to be valued. The management activity is continuously engaged in monitoring the business performances and in controlling that the risks impacting on them were correctly managed. But even more meaningful is the valuation of the product performance at the contract issue time, trying to design the right many-sided future scenario. As long ago as 2007, Easton and Harris ([5]) stated that company's performance and its efficiency are well described by the profitability ratios, referred both to the company as a whole and to a specific business line as life annuities. Understanding the concept of profitability and exploring the efficient way for represent it by means of a synthetic index, is a significant topic; the management can make use of efficient indicators for internal control aims and for communicating outside (to the policyholders and the stakeholders) the health of the company or of a specific portfolio, in other words if and how they give rise to value and profits. Staying in the case of life annuity business, mainly saving products, profitability has to be valued in the long-term perspective, as it is implicit in the contract structure, and taking into account the specific risks impacting on the product under consideration. As clearly explained by Swiss Re 2012 ([9]), the high number of years during which the policy remains in force in the portfolio and the high number of payments in and out of the portfolio, make the performance valuation very difficult. The analysis has to be based on the actuarial control of the payments ([1]) valued on assumptions about the future. The length of the future to take into account in the valuations is the aspect making definitely different the performance measures used in the non life sector, mainly short-term pointed, and the life sector,

with a long-term perspective. These different perspectives make complex the performance valuations at a group level.

Let us consider a portfolio of homogeneous deferred annuities, where each policy is issued to each of N_0 lives aged x, with constant installment R payable at the end of each year while (x) survives and τ the deferment period.

In the case of periodic constant premiums P, paid during all the deferment period with load factor θ, we consider, respectively, the portfolio surplus at time t, S_t, and the "unconstrained" asset at time t, A_t, where:

$$S_t = \sum_j N_j((P + P\theta)\mathbf{1}_{j<\tau} - R\mathbf{1}_{j>\tau})v(t,j) \tag{1}$$

$$A_t = \sum_{j\leq t} N_j(P + P\theta)\mathbf{1}_{j<\tau}v(t,j) - \sum_{j>t} N_j(R\mathbf{1}_{j>\tau} - (P + P\theta)\mathbf{1}_{j<\tau})v(t,j) \tag{2}$$

$v(t,j)$ being the stochastic value at time t of one monetary unit at time j and N_j the number of survivors at time j, belonging to the initial cohort of N_0 lives at time 0.

The influence of the load factors on the life annuity portfolio performance is a crucial issue. Within this context, the ratio $\Psi(\theta) = \frac{[S_t]}{[A_t]}$ provides interesting suggestions concerning correct assessment of the equilibrium between insurer and insured, as well as the appeal of life annuity contracts with the potential insureds.

References

1. Beal, R.W.: Bridging the Gap Between ROE and IRR. *North American Actuarial Journal*, (20029 4: 111.
2. D'Amato, V., Di Lorenzo, E., Haberman, S., Russolillo, M., Sibillo, M.: The Poisson log-bilinear Lee Carter model:Applications of efficient bootstrap methods to annuity analyses.*North American Actuarial Journal*, (2011) **15**, 2: 315-333.
3. De Mey, J.: Reporting on the Financial Performance of Life Insurers. *Geneva Papers on Risk and Insurance*, (2009) 34, 228-241.
4. Di Lorenzo, E., Orlando, A., Sibillo, M.: Risk-profit sharing in actuarial contracts: a profitability analysis, Working Paper (2015).
5. Easton, A. E., Harris J. F.: *Actuarial Aspects of Individual and Annuity Contracts*, second edition, Actex Publication Inc. (2007).
6. Friedman, B. M., Warshawsky, M.: Annuity Prices and Saving Behavior in the United States. NBER Working Paper No. 1683 (Also Reprint No. r1025) (1985).
7. Kraus, C.: EVA/RAROC vs. MCEV Earnings: A Unification Approach. *The Geneva Papers on Risk and Insurance Issues and Practice, December 2012* (2012).
8. Lopes, P.: The Effects of Load Factors and Minimum Size Restrictions on Annuity Market Participation. http://www.lse.ac.uk/finance/people/Teaching Fellows/pdfs and images/lopesAnnuities.pdf
9. Swiss Re: Understanding profitability in life insurance. (2012) http://www.swissre.com/media/news_ releases/nr_20120207_measuring_life _profitability.html.

The riskiness of longevity indexed life annuities in a stochastic Solvency II perspectives

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J.E.L. classification: C13, G22, J11.

Abstract

During the 20th century, in many developed countries human life expectancy has considerably increased. Although past trends suggest that further changes in the level of mortality are to be expected, the future improvements of life expectancy are uncertain and difficult to predict.
This uncertainty about the future development of mortality gives rise to longevity risk. Therefore pension systems are required to design products able to absorb any adverse events concerning the future mortality: the challenge is how to deal with longevity risk. Benefits depend on the survival of a certain number of individuals and the calculation of present values requires an appropriate projection of mortality rates, in order to avoid an underestimation of future liabilities.
Actually this problem is deeply felt by private pension funds. Although the pension market is not well developed in the European countries there is a growing interest of individuals for pension annuities. This is due to a reducion of public system interventions because of costs containment and to a gradual shift from defined benefit schemes to defined contribution systems.
In this context, many pension fund providers focus on the issue of sharing the longevity risk between the annuitants and the annuity provider([2], [3]).
In this paper we try to develop this concept relying on past mortality experience if the italian population measured in the period 1954-2008 in a stochastic Solvency II perspective. A computational tractable approach based on a Lee Carter model for the future uncertainty of the force of mortality is proposed ([5]). Relying on the concept of Value at Risk ([4]), Solvency II implicitly requires to adjust the calculation of the present values in order to take into account market movements in a fair value perspective([6]).
The idea is to adjust the annuity periodic payments considering the survival probabilities thatgradually become available over time. The forecasted probabilites are adjusted in a Solvency II perspectives and are compared with the actual probabilities in order to evaluate the deviations due to life expectancy

improvements ([1])
In order to avoid a monetary penalty for the policyholder, we look for an equilibrium between the reduction in benefits and the deferral of the annuity.

References

1. Denuit, M., Devolder, P., Goderniaux, A.: Securitization of longevity risk. Pricing survivor bonds with Wang trasform in the Lee Carter framework. *Journal of Risk and Insurance* **74** (2007) 87-113.
2. Denuit, M., Haberman, S., Renshaw, A.: Longevity indexed life annuities. *North American Actuarial Journal* **15** (2011) 97-111.
3. Denuit, M., Haberman, S., Renshaw, A.: Longevity-contingent life annuities. *Journal of Pension Economics and Finance* **14** (2015) 315-327.
4. Dowd K.: After VaR: the theory, estimation and insurance application of quantile based risk measures. *Journal of Risk and Insurance* **14** (2015) 315-327.
5. Lee, R.D., Carter, L.: Modeling and forecasting the time series of US mortality. *Journal of the American Statistical Association* **87** (1992) 659-671.
6. Munroe, D., Odell, D., Sandler, S., Zehnwirth, B.: A solution for Solvency II quantitative requirements. Modeling with long tail liabilities. *North American Actuarial Journal* **19** (2015) 79-93.

Risks underlying Loss Portfolio Transfer

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Abstract

Transfer operations claims reserves LPT (Loss Portfolio Transfer) are subject to special financial reinsurance treaties.

Related to such treaties, the transferor transfers to the transferee the obligations for compensation to the risks involved in insurance or reinsurance, related to all or some claims occurring in a fixed period. Despite the commitments made, the transferee receives a reinsurance premium (paid in cash or marketable securities) whose value is commensurate with the current average value of transferred liabilities (provision for claims discounted).

The assessment of affordability, for both parties, requires prior quantification of a number of technical, economic, financial and fiscal components. In particular with regard to technical and actuarial components, for each claim generation under assessment it is necessary to make a detailed estimate of the ultimate cost of claims, the timing of payments; the term structure of interest rates and operating and claims settlement expenses.

Differences of actual values from those estimated configure risks with value of opposite sign to the contractual parties. In particular, they are listed:

- ultimate claims cost risk;
- timing risk;
- interest rate risk;
- expenses risk.

The aim of this paper is to analyze the behavior of the sources of risk that characterize the LPT in order to define a load to be introduced in the premium able to cope whit the risk of the insurance transaction and to cover average costs.

For this purpose a simulative procedure was used based on the inverse Anscombe transformation for the number of claims, the Wilson-Hilferty formula applied to a compound Poisson for the cost of claims and the Ornstein-Uhlenbeck process

for the random component of the cumulative function of the intensity of interest. The simulation has been applied to a hypothetical portfolio of a transferor according to three different scenarios: the first is a baseline scenario, the second scenario allows you to isolate and measure the effects of the function of the structure q (i, j), a component that changes the average frequency claims paid annually; the third scenario is characterized by an increase of the aleatory of the financial habitat where the transferor and the transferee operate.

The numerical application has allowed us to observe that the financial factor has however a limited weight in determining the variability of the transferee, while very important is the influence of insurance factors (portfolio size, timing of settlements, increase of the average annual cost) . In conclusion it is fundamental to investigate the main sources of risk, so that the transferee can limit its exposure by acting directly on individual factors, such as excluding some types of claims, by a maximum coverage, etc...

References

1. Butsic, R.P.: *Determining the proper interest rate for loss reserve discounting: an economic approach.* Casulaty Actuarial Society, New York (1994).
2. Daykin, C.D., Pentikainen, T., Pesonen, M.: *Pratical risk theory for actuaries.* Pratical risk theory for actuaries, Chapman & Hall (1993).
3. DOrtona, N.E., Melisi, G.: Run-off error in the outstanding claims reserves evaluation. *Mathematical and Statistical Methods for Actuarial Sciences and Finance*, Springer (2014) 95-98.
4. Parker, G.: Two stochastic approaches for discounting actuarial functions. *Astin Bulletin* Vol. 24 (1994) 167-181.
5. Pentikainen, T., Rantala, J.: Run-off risk as a part of claims fluctuation. *Astin Bulletin* Vol. 16 (1986) 113-147.
6. Pentikainen, T., Rantala, J.: A simulation procedure for comparing different claims reserving methods. *Astin Bulletin* Vol. 22 (1992) 191-216.

Spatial models for mortality tables: a penalized smooth approach ⋆

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J.E.L. classification: C14, C33.

Abstract

Patterns in mortality are affected by many factors: environmental, economic policies, etc. However, many of this important variables are difficult to measure, or are difficult to include in the classic models to smooth and forecast mortality tables. In many situations the geographical information can be a proxy for those variables, and give interesting insights to the dynamic of mortality at different regions, countries, etc. but, in general, mortality rates are smooth separately at different locations making impossible to carry out any comparison between mortality trends among different geographical areas.

We propose a unified framework that can smooths mortality tables at different locations, accounting for the neighboring relationship among them. The approach is based on the use of penalized regression to smooth and forecast mortality rates, proposed by Currie et al., 2004, and their application to analyze spatio-temporal models (Lee and Durban, 2011). The model can also include covariates in a linear or non-linear form. Furthermore, we propose a general method to disaggregate the number of deaths in order to produce smooth maps of mortality by age or year, or obtain yearly counts when the number of deaths are aggregated in coarse age-intervals. This methodology is based on the *Composite link models* (Thompson and Baker, 1981), and their extension to the semiparametric framework proposed by Eilers (2007).

The methodology proposed will be illustrated with data from mortality tables collected per Spanish province.

References

1. Currie, I., Durban, M., Eilers, P.: Smoothing and forecasting mortality rates. *Statistical Modelling* **4** (2004) 279-298.

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2. Lee, D.-J., Durban, M.: Pspline ANOVA type interaction models for spatio temporal smoothing. *Statistical Modelling* **11**(2011) 49-69
3. Thompson, R., Baker, J.: Composite link functions in generalized linear models. *Journal of the Royal Statistical Society, Series C* **30**(1981) 125-131
4. Eilers, P.: Ill-posed problems with counts, the composite link model and penalized likelihood. *Statistical Modelling* **7**(2007) 239-254

Claim provisioning with development patterns via Hachemeister's credibility

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Abstract

Although more than a century old, the problem of claim provisioning is very far from having found a sound and widely recognized method for its solution. In addition, the introduction of Solvency II in Europe forces the insurance industry not only to point out an estimation of the mean of outstanding claims and maybe of their variance, as presented in Mack's theory (see [?]), but also to number their quantiles in the context of the VaR-operator, in order to determine the solvency capital requirement (SCR).

On the other hand, there is a tremendous discrepancy between the simplistic methods applied in claim provisioning, like in Chain-Ladder, in the additive model or in the Bornhuetter-Ferguson principle, and the huge amount of data realizing the development of claim payments, which are treasured in insurance companies (see also the remarks in [?]). Almost none of the hidden structures inherent in these data is revealed and sensibly applied for provisioning. This observation serves as starting point for the present model.

The fundamental ideas of our model are as follows: First, the property that at a certain level of a Bayesian hierarchy, the development pattern of a claim, i.e. the development of the proportion of the payment of a claim at a given development year with respect to its final payment, is almost independent of the final amount of the claim. Second, there is a relatively small number of characteristic development patterns and the development of each claim follows more or less one of these characteristic patterns. However, since for each claim only a small number of development years are known, the attribution to one of them is not exactly possible. So we only require that the development pattern of a claim is a convex combination of the characteristic ones. It is worthwhile reminding the reader that almost all of the usual models for provisioning, like Chain-Ladder, the additive model, the loss development method, or the Bornhuetter-Ferguson method know only one single development pattern (see [?]).

The incorporation of these basic ideas into a proper mathematical model requires the following structural phenomena. In addition to each accident year, we have to deal with each contract, active at this year and producing a claim. This structure can be described as claim-level or micro-level provisioning (cf. [?]). We realize this phenomenon by a Bayesian hierarchy with two levels of hidden structural variables, one (Λ_i) for the accident year and one ($\Lambda_{i,k}$) for the claim. Second, the characteristic development pattern, once found, are naturally combined in a design matrix

as known from Hachemeister's credibility theory (see [**?**]). So we are immediately faced with a multi-level hierarchical Hachemreister's credibility model, as treated for linear models in a very general way by R. Norberg in [**?**]. However, by separating the payments of a claim into its development pattern and its final claim amount, our model will become one of a non-linear hierarchical Hachemeister's credibility theory.

As to be expected, the non-linearity of the model not only increases the number of parameters to be estimated considerably, but – what is more important – makes some of them mutually interweaved. On top of it appears the task to estimate the covariance matrix of the observable variables on the ground level. In standard linear credibility, this matrix, except for a scalar term, is usually supposed to be known (see e.g. [**?**]). So it is not surprising that we end up with a number of interweaved pseudo-estimators requiring an iterative procedure for their solutions.

Another problem is the construction of the design matrix whose columns should consist of the characteristic development patterns. Here, the missing data of future development years are a particular nuisance. Our first approach via a hierarchical clustering which took only the observed data in consideration failed. Finally, we opt for an iteration procedure whose starting configuration consists of a first completion of the missing data by a standard method of provisioning, for example by the additive model. With these completed data, we proceed by a flexible application of the well-known k means clustering method, where the number k of clusters may vary between 1 and a given maximal number of characteristic development patterns. The choice which number will finally be retained is done via a scoring function of the different cluster configurations. The applied scoring function is a special version of the known *Bayesian information criterion* (see [**?**]).

Once the design matrix found, we run through the calculation of the estimators mentioned before. The estimation of these parameters allows us to determine the credibility estimator of the development pattern for each claim and accident year. The estimated final payment for the claim results from an easy regression problem. The knowledge of estimated development pattern and final payment allows to complete the data again by the estimation of future years and we can rerun our iteration procedure until an almost invariant state is found.

In [**?**], the ideas of Norberg are applied to an extensive case study, where a parametric distribution is attached to each claim. The study differentiates between types of claims and between incurred-but-not-reported and reported-but-not-settled claims.

Generally speaking, it can be noticed that claim-level models prove more successful than the aggregate ones.

References

1. Antonio, K., Plat, R.: Micro-level stochastic loss reserving for general insurance. *Scandinavian Actuarial Jour.* **7** (2014) 649-699.
2. England, P., Verrall, R.: Stochastic claim reserving in general insurance. *British Actuarial Jour.* **8** (2002) 443-544.
3. Mack, T.: Improved estimation of IBNR claims by credibility theory. *Insurance: Mathem. a. Econom.* **9** (1990) 51-57.
4. Hachemeister, C.A.: Credibility for regression models with application to trend in Credibility, theory and application. *Proceedings of the Berkeley Actuarial Research Conference on credibility; Academic Press, New York.* (1975) 129-163.
5. Norberg, R.: Hierarchical credibility: analysis of a random effect linear model with nested classification. *Scandinavian Actuarial Jour.* (1986) 204-222.
6. Pelleg, D., Moore, A.: X-means: Extending K-means with efficient estimation of Numbers of Clusters. *Proceedings Int. Conf. Machine Learning ICML* (2000) 727-734.
7. Schmidt, K. D.: Loss prediction based on run-off triangles. *Adv. Statistical Analysis* **96** (2012) 265-310.

Capital allocation for MTPL insurance in the presence of black box

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Abstract

In the context of MTPL tariffs exists the possibility for drivers to install on their cars electronic mechanisms, so called black boxes, that allow the insurance company to record the activity of the vehicle and thus avoid, among other things, simulations of claims.

The black box has many positive effects on the number of claims and average cost: a selection of policyholders through the installation of the black box, which leads to the formation of a less risky portfolio of insured; the improvement of the accident claims resulting from the fact that the insured feel controlled by the black box; all the benefits that flow from control of the dynamics of claims and related costs.

The more information available to the companies allows, by actuarial techniques, construction of the so-called ”pay per use” insurance in which the insured is aware of how much it costs per kilometer in various driving conditions or tariffs based on a points system, ”pay as you drive” in which the insured consumes points according to the mode of driving.

For these innovative insurance products it is difficult to apply the traditional techniques for the reservation and the corresponding allocation of capital.

The present work has the objective to build a model for the determination of the capital allocation as possible commensurate to the specific level of claims in each risk assumed, through the identification of synthetic indicators of driving behavior likely to become variables of tariff (risk factors) that can significantly influence the accident rate. The statistical models used have been tested in order to measure the accuracy of the estimates of the models themselves, and to identify a statistical model able to explain the variability of the portfolio.

The elaborated practical application start from the analysis of data collected by a company specializing in the provision of telematics services and systems for the insurance and automotive market, and able to record and process statistical

information on the driving habits of motorists through the installation the black box.

In particular, based on a profile of the assumed portfolio, the insured individual characteristics and considering the estimated rating factors with GLM, via simulation, the authors determine the best estimate of the premium reserve, the capital to be allocated to cover the premium risk and, consequently the risk margin to be added to the BE to get the fair value of the premium reserve.

Furthermore, in a Solvency II perspective, the capital requirement is determined against the premium risk based on the internal model proposed and is compared with the standard formula proposed by EIOPA.

References

1. Altman, E.: Financial Ratios, Discriminant Analysis and The Prediction of Corporate Bankruptcy. *The Journal of Finance*, Vol. 23 (4) (1968) 589-608.
2. Bordoff, E.J., Pascal, J.N.: *Pay-As-You- Drive Auto Insurance: A Simple Way To Reduce Driving-Related Harms and Increase Equity*, Discussion paper. The Hamilton Project, The Brooking Institution (2008).
3. Gigante, P., Picech, L., Sigalotti, L.: *La tariffazione nei rami danni con modelli lineari generalizzati.* EUT, (2010).
4. Kelly, M., Isotupa, S., Kleffner, A.: The Impact of Adjuster Moral Hazard on Driving Records. *North American Actuarial Journal*, Vol. 13 (4) (2010) 425-437.
5. Klugman, S., Panjer, H., Willmot, G.: *Loss Models. From Data to Decisions.* John Wiley & Sons, INC. (2008).
6. Lambert, D.: Zero-Inflated Poisson Regression, with an Application to Defects in Manufacturing. *Technometrics*, Vol. 34 (1) (1992).
7. Makov, U.: *Evolution of Data Use in UBI.* Annual Meeting of Casual Actuarial Society, (2011).

Construction of a dynamic life-table adapted to the Algerian retired population mortality experience

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J.E.L. classification: C13, G22, J11.

Abstract

Life expectancy is still improving in the developing countries; this improvement is almost different by sub-population. Mortality of the retired population is often lower compared to the global population. The use of a dynamic life-tables based on global population data might distort all calculations when used for pension plan reserving. The use of life tables adapted to the retired population mortality experience is more suitable for this issue. Generally, the data of the insured population is not available for a long period allowing to do a robust forecast. Also, this data is issue from reduced sample of population compared to the global population which leads to important irregularities related to the reduced population at risk. In such a case, the direct use of the stochastic mortality models such Lee-Carter [4] or Cairns-Blake-Dowd models [2] to predict the future mortality trends is not practical at all. For this, some methods were proposed to consider the particularities of the insured population mortality while ensuring a good fitting quality and strong forecasting capacity. These methods aim to position the experience life table to an external reference [5][6]. The main idea was to define a relationship regression between the specific death rates and the baseline death rates. This process is principally based on the Brass Logit system [1]. The use of the baseline life table to estimate mortality schemes starting from incomplete or imperfect mortality data has become a common practice for experience life-tables construction both in developed and developing countries. Kamega (2011) used the same approach to estimate actuarial life table for some centre-African countries [7] with taking the French life tables as an external reference (TGH05 and TGF05). The main objective for the present work is to construct a prospective life table based on the mortality data of the Algerian retired population. The data is available for ten years (2004 to 2013) and for the ages [50, 99] arranged by five- age intervals. This data concerns the observed

number of deaths and the survivals number by the end of each year of the observation period. We have tried earlier to construct a prospective life-table based on the global population mortality data [3]. The length of the observed data allows doing a strong forecast. Here, we use this life table as a baseline mortality to position the experience life table that we aim to construct by the present work. Finally, the obtained results will be used for life-annuities pricing and reserving comparatively with the results obtained with the global population life table.

References

1. Brass, W.: On the scale of mortality. W. Brass (ed.). *Biological Aspects of Demography.* London: Taylor and Francis. (1971).
2. Cairns, A.J.G., Blake, D., and Dowd, K.:A two-factor model for stochastic mortality with parameter uncertainty: Theory and calibration. *Journal of Risk and Insurance*, 73: 687-718.(2006)
3. Flici, F.: Longevity and life-annuities reserving in Algeria. *Conference paper. East Asian Actuarial Association Conference.* Taipei, Taiwan. Lisbon. (2014).
4. Lee, R. D. and Carter, L. R.:Modeling and forecasting U. S. Mortality. *Journal of American statistical association.* 87, 419, 659 671.(1992)
5. Planchet, F.: Tables de mortalit dexprience pour des portefeuilles de rentiers. *Note mthodologique de lInstitut des Actuaires.* (2005)
6. Planchet, F.: Construction des tables de mortalit dexprience pour les portefeuilles de rentiers prsentation de la mthode de construction. *Note mthodologique de lInstitut des Actuaires.* (2006).
7. Kamega, A.: *Outils theoriques et operationnels adaptes au contexte de l'assurance vie en Afrique subsaharienne francophone - Analyse et mesure des risques lies a la mortalite*, Doctoral Dissertation. Universite Claude Bernard - Lyon I. France. (2011).

Analysis of calibration risk for exotic options through a resampling technique.

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J.E.L. classification: G13, G19.

Abstract

Substantial losses suffered by financial institutions, due to mispricing of financial derivatives in the last decades, has lead regulators to address model risk. The Basel Committee on Banking Supervision identifies two types of model risk: the risk associated with possibly incorrect evaluation of complex products and calibration risk which arises from unobservable model parameters. This risk has to be assessed by financial institutions and valuation adjustments should be introduced to account for it. The Federal Reserve has drawn guidelines for an active management of model risk. Among other things, the document suggests that banks should employ sensitivity analysis in model development and validation to check the impact of small changes in inputs and parameter values on model outputs. The European Banking Authority has set out requirements relating to additional valuation adjustments (AVA) of fair-valued positions to determine prudent values of balance sheets, which should cover valuation model risk, "which arises due to the potential existence of a range of different models or model calibrations, which are used by market participants, and the lack of a firm exit price for the specific product being valued." Cont [2] has built a theoretical framework, extended by Gupta et al. [6], for the quantification of model uncertainty. In the context of exotic option prices, Schoutens et al. [7] have analyzed model risk, i.e. the risk related to pricing options using a wrong model, in an empirical study. Moreover, even if an appropriate model has been chosen, so that model risk is ruled out, the calibration procedure of option pricing models to market data has a relevant impact on exotic option prices. This involves several risk dimensions. Detlefsen et al. [3] have studied calibration risk as arising from the use of different loss functions. Guillaume and Schoutens [5]

extend this concept to include the calibration methodology. Gilli and Schumann [4] have examined the use of different calibration algorithms.

In this paper, we focus on another dimension of calibration risk, which arises from the estimation error of calibrated model parameters and carries over to exotic prices. We quantify its impact for some popular option pricing models through a parametric bootstrapping technique. From an econometric point of view, the calibration of the parameters of the preferred model to market quantities consists of a non linear least squares regression. Using asymptotic results, we obtain the bootstrap distribution of the exotic derivative prices. This allows us to compute confidence intervals of exotic option prices that contain the same information brought by the original sample, thus quantifying estimation risk.

We provide empirical evidence of calibration risk for exotic options on a time series of EURO STOXX 50 implied volatility surfaces, covering a one year period. It turns out that complex pricing models provide a better fit to liquid market data, but at a cost of higher uncertainty in pricing exotic products, for which estimation risk can be substantial. Furthermore, we perform a sensitivity analysis along the lines proposed in Baucells and Borgonovo [1]. In finance, a standard way of performing a sensitivity analysis is to compute the so-called option Greeks with respect to the model parameters. However, a fatal limitation of this approach is that, due its intrinsic local nature, it does not take into account model non-linearities and presence of correlations among the unknown model inputs parameters. A natural way to take into account this is the probabilistic Sensitivity Analysis in [1] that identifies key sources of uncertainty in the model output with respect to the uncertainty in model parameters. Our boostrap procedure makes viable the sensitivity analysis for option pricing and for quantitative assessment of the model valuation adjustment. This can be of some value for regulators and risk-managers.

References

1. Baucells M., Borgonovo E.: Invariant Probabilistic Sensitivity Analysis. *Management Science*, **59(11)** (2013) 2536-2549.
2. Cont, R.: Model uncertainty and its impact on the pricing of derivative instruments. *Mathematical Finance* **16(2)** (2006) 519-547.
3. Detlefsen, K., Hardle, W.K.: Calibration risk for exotic options. *The Journal of Derivatives* **14(4)** (2007) 47-63.
4. Gilli, M., Schumann, E.: Calibrating Option Pricing Models with Heuristics. In Brabazon A., O'Neill, M., Maringer, D. (eds.): *NATURAL COMPUTING IN COMPUTATIONAL FINANCE*, Vol. 4, Springer (2011).
5. Guillaume, F.,Schoutens, W.: Calibration risk: Illustrating the impact of calibration risk under the Heston model. *Review of Derivatives Research* **15(1)** (2012) 57-79.
6. Gupta, A., Reisinger, C., Whitley, A.: Model uncertainty and its impact on derivative pricing. In Bocker K. (ed.): *Rethinking Risk Management and Reporting*, Vol. II, RiskBooks (2010) 137-176.
7. Schoutens, W., Simons, E., Tistaert, J.: A perfect calibration! Now what? *Wilmott* (2004) 66-78.

Estimating Value-at-Risks (VaR) using multivariate copula-based volatility models

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J.E.L. classification: C15, C58, G11, G32.

Abstract

Research have overwhelming shown evidence that majority of asset returns are not normally distributed as previously claimed. Asset returns do exhibit heavy tails with evidence of changing volatility and significant serial correlations. Traditional VaR model, because of the normality assumption, do not actually account for the tail distribution of asset returns since normality assumption will imply lighter tails of asset returns while ignoring big losses. Non-normality for univariate models is related to skewed distributions and high excess kurtosis while for multivariate models, it is the joint probability of large market movements referred to as *tail dependence* [1]. Copula functions, introduced by [6], are used to model these tail dependence of large market movements. Copulas were first introduced in finance by [2], and [4] and have since been very popular in financial time series analysis [3].

In this paper, we estimate VaR for banks in some selected European countries over a period of 2 January 2007 to 8 April 2015 using gaussian and t-copulas, and checked the accuracy of the models by performing some back-testing techniques.

Theorem 1. *Sklar's theorem: Let* $F_1(x), F_2(y)$ *be marginal distribution functions. Then, for every* $(x, y) \in \Re^{*2}$*:*

- *if c is any subcopula whose domain contains Ran* F_1 *x Ran* F_2*,*

$$c(F_1(x), F_2(y))$$

  is a joint distribution function with margins $F_1(x), F_2(y)$*.*
- *also, if* $F(x, y)$ *is a joint distribution function with margins* $F_1(x), F_2(y)$*, there exist a unique subcopula c, with domain Ran* F_1 *x Ran* F_2*, such that*

$$F(x, y) = c(F_1(x), F_2(y))$$

If $F_1(x), F_2(y)$ *are continuous, the subcopula is a copula; if not, there exist a copula* C *such that*

$$C(\upsilon, z) = c(\upsilon, z)$$

for every $(\upsilon, z) \in$ *Ran* F_1x *Ran* F_2 *[1]*

Definition 1. *An* $n-$ *dimensional copula* $C(u_1, u_1, u_1, \cdots, u_n)^{'}$ *is a distribution function on* $[0,1]^n$ *with standard uniform marginal distributions, where* $[0,1]$ *is a unit interval on the real line [5].*

Consider a random vector $X = (x_1, \cdots, x_n)^{'}$, with margins $F(x_1), \cdots, F(x_n)$, then from theorem 1:

$$F(x_1, \cdots, x_n) = C(F(x_1), \cdots, F(x_n)). \tag{1}$$

C is unique if $F(x_1), \cdots, F(x_n)$ are continuous, else C is uniquely determined on $[0,1]^n$. On the other hand, if C is a copula, and $F_1, \cdots, F_n$ are univariate distribution functions, Eq.(1) is a joint distribution function with margins $F_1, \cdots, F_n$ [3], [5].

References

1. Cherubini, U., Luciano, E., Vecchiato W.: *Copula methods in finance.* John Wiley & Sons, 2004.
2. Frey, R., McNeil, A.J.: Modelling dependent defaults. *ETH, Eidgenössische Technische Hochschule Zürich, Department of Mathematics*, 2001.
3. Alexios, G.: *The rmgarch models: Background and properties.* (version 1.2-8). URL http://cran.r-project. org/web/packages/rmgarch/index. html, 2014.
4. Li, David X.: On default correlation: A copula function approach. Available at *SSRN 187289*, 1999.
5. Tsay, R.S..: *Multivariate Time Series Analysis: With R and Financial Applications.* John Wiley & Sons, 2013.
6. Sklar, M.: *Fonctions de répartition à n dimensions et leurs marges.* Université Paris 8, 1959.

Stock market volatility and economic variables: a nonlinear approach

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Abstract

From an empirical perspective the link between macroeconomic variables and stock market volatility has been analyzed using different models and sample periods, classical papers on the topic are [8] and [12]; recent examples are [1], [3], [4], [5], and [9]. A number of empirical studies find that the volatility of stock returns is higher in bad times than in good times (see, e.g., [2] and the additional evidence provided here). [7] shows that return volatility is countercyclical because risk premia change asymmetrically in response to variations in economic conditions.

In this paper we extend the analysis and look at the relationship between aggregate stock market volatility and financial and economic variables adopting the dynamic smooth transition regression (DSTR) model. DSTR belongs to a class of models for which it is explicitly assumed that the regime switch is endogenously determined by an observed state variable. This choice is coherent with the empirical evidence that aggregate stock market volatility behaves countercyclically, i.e. is higher during recessions and lower in expansions. Being able to model the evolution of the process driving such changes and hence the switch from one state to another must surely make for a better understanding of the underlying dynamics and perhaps lead to a better forecast model. A review of recent extensions and the state of research in the area of nonlinear modeling can be found in [13]. We rely on the ex-post measurement of volatility (monthly realized variance series), based on daily frequency data, on a long time span (from 1926 through 2013). We propose alternative specifications of dynamic smooth transition regression models that include lagged exogenous variables. We restrict our attention to the case of two regimes where the transition can depend on exogenous variables. Nonlinear models based on macroeconomic and financial predictors are able to forecast the states of the stock volatility. The long sample used in the analysis suggests the adoption of a more flexible specification to accommodate possible structural breaks in the form of a time-varying parameters.

References

1. Asgharian, H., Hou, A. J., Javed, F.: The importance of the macroeconomic variables in forecasting stock return variance: A GARCH-MIDAS approach. *J*ournal of Forecasting **32(7)** (2013) 600–612.
2. Brandt, M. and Kang, Q.: On the relationship between the conditional mean and volatility of stock returns: a latent VAR approach. *J*ournal of Financial Economics **72** (2004) 217–257.
3. Campbell, S. and Diebold, F.: Stock returns and expected business conditions: half a century of evidence. *J*ournal of Business & Economic Statistics **27** (2009) 266–278.
4. Christiansen, C., M.Schmeling, and Schrimpf, A.: A comprehensive look at financial volatility prediction by economic variables. *J*ournal of Applied Econometrics **27** (2012) 956–977.
5. Corradi, V., Distaso, W., and Mele, A.: Macroeconomic determinants of stock volatility and volatility premiums. *J*ournal of Monetary Economics **60(2)** (2013) 203 – 220.
6. French, K. R., Schwert, G., and Stambaugh, R. F. (1987). Expected stock returns and volatility. *Journal of Financial Economics*, 19(1):3 – 29.
7. Mele, A.: Asymmetric stock market volatility and the cyclical behavior of expected returns. *J*ournal of Financial Economics **86(2)** (2007) 446 – 478.
8. Officer, R. R.: The variability of the market factor of the New York Stock Exchange. *T*he Journal of Business **46(3)** (1973) 434–453.
9. Paye, B.: Déjà vol: Predictive regressions for aggregate stock market volatility using macroeconomic variables. *J*ournal of Financial Economics **106** (2012) 527–546.
10. Poterba, J. M. and Summers, L. H.: The persistence of volatility and stock market fluctuations. *T*he American Economic Review **76(5)** (1986) 1142–1151.
11. Schwert, G.: Business cycles, financial crises, and stock volatility. *C*arnegie-Rochester Conference Series on Public Policy **31(0)** (1989a) 83 – 125.
12. Schwert, G. W.: Why does stock market volatility change over time? *T*he Journal of Finance **44(5)** (1989b) 1115–1153.
13. Teräsvirta, T., Tjøstheim, D., and Granger, C. W. J.: *M*odelling nonlinear economic time series (2010) Oxford University Press, Oxford.

Modeling volatility risk premium

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J.E.L. classification: C60, G17.

Abstract

The variance process of a determined underlying asset S is not traded on the market in general. Thus, all the volatility products cannot be study in a model free basis due to the lack of available data. In continuous time framework, the bias between the expected integrated variance under the historical and the risk neutral probability introduced the concept of the risk premium. In general, the expression of the variance risk premium at time t is given by $VRP_t^T = \mathbb{E}(RV_{t,T}\big|\mathcal{F}_t) - \mathbb{E}^*(RV_{t,T}\big|\mathcal{F}_t), \quad 0 \leq t \leq T$. The quantity $RV_{t,T}$ represents the realised variance over the period $[t,T]$ of a determined underlying asset S. In this paper, we investigate the price of the volatility risk premium in the case of a parametric semi-linear class of continuous time diffusion of the spot-variance process. We use some basic tools of Malliavin Calculus to provide a backward representation of the variance risk premium process. We will provide some applications and discuss the particular case of the Heston model.

We consider a filtered probability space $(\Omega, \mathcal{F}, \mathbb{P}, \mathbb{F})$, $\mathbb{F} = (\mathcal{F}_t)_{0\leq t\leq T}$ a complete natural filtration of a 1-dimensional standard Brownian motion W. We assumed that under the historical probability $\mathbb{P}$, the variance process of the underlying asset S is described by the following Itô process

$$dV_t = \beta(V_t)dt + \sigma(V_t)dW_t, \quad V_0 = v_0 > 0, \quad \beta(x) = b(x) - ax. \tag{1}$$

In the context of pricing in finance, we assumed there exists a unique risk neutral probability $\mathbb{P}^*$ under which the risk neutral dynamic of the variance is given by the following stochastic differential equation

$$dV_t = \beta^*(V_t)dt + \sigma^*(V_t)dW_t^*; \quad V_0 = v_0 > 0, \quad \beta^*(x) = b^*(x) - a^*x. \tag{2}$$

where W^* is a Brownian motion under the measure $\mathbb{P}^*$. We assume that the solution of the two above equations exists and are unique such that

$$\mathbb{P}\big(\forall t \in [0,T], V_t > 0\big) + \mathbb{P}^*\big(\forall t \in [0,T], V_t > 0\big) = 2. \tag{3}$$

We also assume that :

- the couple $(a, a^*) \neq (0, 0)$
- the functions $b, b^*, \sigma > 0, \sigma^* > 0$ are regular enough with a bounded spacial derivative almost surely
- the Malliavin derivative of X and X^* exist and are unique.

Proposition 1. *Under some regularity assumptions, we have the following backward representation of the variance risk premium process. For* $t \in [0, T]$ *and some* $B_{T,t}$ *and* $B^*_{T,t}$ *we have:*

$$\begin{aligned}
VRP_t^T &= \frac{1}{a^*(T-t)} \int_t^T \sigma^*(V_s) dW_s^* - \frac{1}{a(T-t)} \int_t^T \sigma(V_s) dW_s - B_{T,t} + B^*_{T,t} \\
&\quad + \frac{1}{aa^*(T-t)} \left[\int_t^T a^* \mathbb{E}_s \Big(D_s \big[\mathbb{E}_t (V_T) \big] \Big) dW_s - \int_t^T a \mathbb{E}_s^* \Big(D_s^* \big[\mathbb{E}_t^* (V_T) \big] \Big) dW_s^* \right] \\
VRP_T^T &= 0
\end{aligned}$$

Proposition 2 (Linear Case). *If* $\beta(x) = \mu - ax$ *and* $\beta^*(x) = \mu^* - a^*x$ *, the variance risk premium admits the following backward representation.*
For $t \in [0, T]$

$$\begin{aligned}
VRP_t^T &= \frac{1}{a(T-t)} \left(\int_t^T e^{-a(T-t)} \mathbb{E}_s \left(D_s V_t \right) dW_s - \int_t^T \sigma(V_s) dW_s \right) \\
&\quad - \frac{1}{a^*(T-t)} \left(\int_t^T e^{-a^*(T-t)} \mathbb{E}_s^* \left(D_s^* V_t \right) dW_s^* + \int_t^T \sigma^*(V_s) dW_s^* \right) \\
VRP_T^T &= 0
\end{aligned}$$

It is well known that the times series in financial market are not continuous in general. A possible extension of this work in to take into account the jump behavior of the underlying volatility process.

References

1. Carr, P. and Wu, L.: *Variance risk premiums.* In Review of Financial Studies 22.3, (2009) 1311-1341.
2. Nualart, D.: *The Malliavin calculus and related topics.* Springer-Verlag, 1995.
3. Lamberton, D. and Lapeyre, B.: *Introduction to stochastic calculus applied to finance*, CRC press, (2007).
4. Bollerslev, T. and Gibson, M. and Zhou, H.: *Dynamic estimation of volatility risk premia and investor risk aversion from option-implied and realized volatilities.* Journal of econometrics, Berlin (2011).

Linking pensions to life expectancy: a solution to guarantee long-term sustainability?*

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J.E.L. classification: E62, H55, J11, J26.

Abstract

The decline in fertility rates, the increase in longevity and the current forecasts for the ageing of the baby-boom generation all point to a substantial increase in the age dependency ratio, and this will raise serious concerns for the sustainability of Pay-As-You-Go (PAYG) pension systems. This is a worldwide problem, and consequently, many European countries have already carried out some parametric reform, or even structural reforms, of their pension systems.

In the meantime, some countries have decided to set up Automatic Balancing Mechanisms (ABMs). ABMs are defined, Vidal-Meliá et al. [4], as a set of predetermined measures established by law to be applied immediately as required according to an indicator that reflects the financial health of the system. Its purpose, through successive application, is to re-establish the financial equilibrium of PAYG pension systems without the repeated intervention of the legislator.

In this line, Godínez-Olivares et al. [2] design a new ABM to restore the liquidity into the system under a nonlinear dynamic programming framework. This ABM is the result of minimizing a chosen logarithmic function and simultaneously calculating the optimal path for the contribution rate, retirement age and indexation of pensions for a PAYG system. According to D'Addio and

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Whitehouse [1] three main automatic mechanisms can be considered for changing pension values. First, adjustments can be made in benefit levels to reflect changes in life expectancy; second, adjustments can be made through revalorization of earlier years' contribution bases and third, adjustments may occur through the indexation of pension payments. In fact, two-thirds of pension reforms in OECD countries in the last 15 years, OECD [3], contain measures that will automatically link future pensions to changes in life expectancy.

With this in mind, the aim of this paper is to twofold. First, using nonlinear optimization, it seeks to assess whether a sustainability factor linked to life expectancy is sufficient to guarantee the financial stability in the pension system. Secondly, considering this sustainability factor, it designs different optimal strategies, that involve variables such as the contribution rate, age of retirement and indexation on pensions, to restore the long-term financial equilibrium of the system. These optimal strategies, which we call ABM, calculate the optimal path of these variables over time and absorb fluctuations in longevity, fertility rates, salary growth or any other kind of uncertainty faced by the pension system.

References

1. D'Addio, A. C., Whitehouse, E.: Towards Financial Sustainability of Pension Systems: The Role of Automatic-Adjustment Mechanisms in OECD and EU Countries. *Bundesamt für Sozialversicherungen* (2012).
2. Godínez-Olivares, H., Boado-Penas, C., Pantelous, A.: How to finance pensions: Optimal strategies for pay-as-you-go pension systems. *Journal of Forecasting* ISSN 1099-131X (Online); 0277-6693 (Print) (In Press) (2015) 1-30.
3. OECD.: Linking Pensions to Life Expectancy *Pensions at a Glance 2011: Retirement-income Systems in OECD and G20 Countries, OECD Publishing.* (2011).
4. Vidal-Meliá, C., Boado-Penas, M.C., Settergren, O.: Automatic Balance Mechanisms in Pay-As-You-Go Pension Systems. *Geneva Papers on Risk and Insurance* **34** (2009) 287-317.

The Spectral Stress VaR (SSVaR)*

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J.E.L. classification: C13, C14, C15, G28, G32.

Abstract

One of the key lessons of the crisis which began in 2007 has been the need to strengthen the risk coverage of the capital framework. In response, the Basel Committee in July 2009 completed a number of critical reforms to the Basel II framework. One of the reforms is to introduce a stressed value-at-risk (VaR) capital requirement based on a continuous 12-month period of significant financial stress (Basel Committee on Banking Supervision 2011). However the Basel framework does not specify a model to calculate the stressed VaR and leaves it up to the banks to develop an appropriate internal model to capture risks they face. Consequently we propose a forward stress risk measure "spectral stress VaR" (SSVaR) as an implementation model of stressed VaR, by exploiting asymptotic normality of an estimator of VaR. In particular to allow SSVaR incorporating the tail structure information we perform the spectral analysis to build it. Using a data set composed of operational risk factors we fit a panel of distributions to construct the SSVaR in order to stress it. Additionally we show how the SSVaR can be an indicator regarding an inner model robustness for the banks.

Theorem 1. *We recall the theorem of Rao (2001) [1]. Let* $X_1, ..., X_n$ *be a sequence of i.i.d r.v. whose continuous and strictly monotonic distribution is* F, f *the associated continuous density,* $0 < p < 1$ *a given number and* np *is assumed not to be an integer, if we denote* ξ_p *the quantile associated to* F *at level* p*, then the order statistic* $\hat{\xi}_{p_n}$ *has the following property:* [1]

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[1] The quantile ξ_p corresponds to the VaR_p, thus the distribution of $\widehat{VaR}_p$ based on the order statistics of $X_1, ..., X_n$ is provided by this theorem. Note that $\hat{\xi}_{p_n} := X_{([np]+1)}$.

$$\hat{u}_{p_n} = \frac{\hat{\xi}_{p_n} - \xi_p}{\sqrt{V}} \rightarrow N(0,1), \quad as \quad n \longrightarrow \infty \tag{1}$$

where

$$V = \frac{p(1-p)}{f(\xi_p)^2 n}. \tag{2}$$

From the Theorem 1, we can build a confidence interval CI_q with $0 < q < 1$ around the true unknown VaR_p:

$$\xi_p \in \left[\hat{\xi}_{p_n} - z_{\frac{1+q}{2}}\sqrt{V}, \quad \hat{\xi}_{p_n} + z_{\frac{1+q}{2}}\sqrt{V}\right] \tag{3}$$

We use Theorem 1 to build a confidence interval CI_q around VaR_p. It is important to point out that CI_q depends on the unknown distribution f , the sample size n of the data set, the confidence level p of VaR_p and the confidence level q of CI_q. we use this confidence interval to determine an area whose lower bound is VaR_p and upper bound is the upper bound of the confidence interval: this area corresponds to a new risk measure SSVaR that we can use to take into account the uncertainty of traditional VaR model.

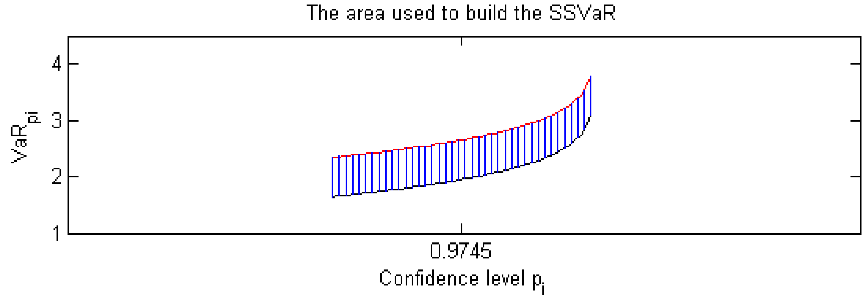

Fig. 1. We provide the area corresponding to the SSVaR, the lower bound corresponds to VaR_{p_i} and the upper bound to the upper bound of $CI_{q_i,p_i}, i = 1, ..., k$.

References

1. Rao, C.R.: *Linear statistical inference and its applications.* Wiley-Interscience, Hoboken, New Jersey (2001).
2. Guégan, D., Hassani, B.: Stress testing engineering: the real risk measurement. In: Bensoussan, A., Guégan, D., Tapiero, C. (ed) *Future Perspective in Risk Models and Finance*, 1st edn. Springer International Publishing, New York (2015) 89-124.

Statistical modelling on the severity of road accidents in United Kingdom for year 2013

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J.E.L. classification: C380, C390.

Abstract

The attempts to reduce road accidents have emerged as a vital public health endeavour for the past decades [1, 2]. Social and economic costs involved in road accidents were undeniably high and it create a development crisis within the nation [3]. Despite of the large magnitude of loss, traffic accident still remains a low priority attention for higher authorities and other associated agencies. Hence, it requires concerted effort at the international, national and local levels for effective and sustainable prevention in order to reduce traffic casualties [4].

Considerable past research has explored relationships between accident frequency and its factor, but relatively little research has examined factors that contribute to each type of accident severity (fatal, serious and slight). The objective of this research is to gain a better understanding of the factors that affect the likelihood of a road crash, thus will producing better crash prediction and providing direction in reducing number of crashes for different types of accident severity. The obtained information will be used to develop more advanced statistical model in the future.

In the United Kingdom (UK), there is an alarming rate of road accident injuries and deaths during the recent years. Road crashes killed 1,713 people and injured or disabled another 21,657 people in year 2013 [5].The required data was extracted from UK Data Archive databases which include personal details of drivers and injuries, as well as temporal, geographical, environmental and accident characteristics.

The research analysis was conducted in two phases. In the first stage, an exploratory data analysis technique (two-step cluster method) was performed in which the study of 138,660 accident cases was divided into two separate groups of clusters according to the three types of accident severity. In the second part, statistical modelling of road crashes given with a set of potential contributing factors were analysed by applying multinomial logistic regression and graphical model separately for each cluster. Multinomial logistic regression is selected to determine the effect of multiple accident factors formulated simultaneously to predict the association for each category of accident severity. Three steps were involved, including finding the best fitted model, analysing significant variables

and interpreting the variables. For graphical model, it is used to explain conditional independence relationships between variables in order to identify direct and indirect association of accident contributing factors and its severity.

The unique contributions of this research are the application of cluster analysis, followed by multinomial logistic regression and graphical model to provide some statistical evidence in explaining the severity of road accidents in the UK for year 2013.

References

1. Peden M., Scurfield R., Sleet D.A, Mohan D., Hyder A.A., Jarawan E., Mathers C.: World report on road traffic injury prevention *World Health Organization*, Geneva (2004).
2. Peden, M., Sminkey, L.: World Health Organization dedicates World Health Day to road safety *Injury prevention*. BMJ Publishing Group Ltd. **10** (2004) 67.
3. Sleet D.A., Dinh-Zarr T. B., Dellinger A. M.: Traffic safety in the context of public health and medicine. *Improving Traffic Safety Culture in the United States* **41** (2007).
4. World Health Organization: Global status report on road safety: time for action. *World Health Organization* (2009).
5. Department for Transport: Reported Road Casualties Great Britain: 2013. *Department for Transport*, Annual Report. (2014).

Loss coverage in insurance markets: why adverse selection is not always a bad thing

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J.E.L. classification: G22, G28.

Abstract

Insurers hope to make profit through pooling policies from a large number of individuals. Unless the risk in question is similar for all potential customers, an insurer is exposed to the possibility of adverse selection by attracting only high-risk individuals. To counter this, insurers have traditionally employed underwriting principles, to identify suitable risk factors to subdivide their potential customers into homogeneous risk groups, based on which risk-related premiums can be charged.

In reality, however, insurers may not have all the information reflecting individuals' risks due to information asymmetry or restrictions on using certain risk factors in their underwriting process. In either case, conventional wisdom suggests that the absence of risk classification in an insurance market is likely to lead eventually to a collapse of the whole insurance system, i.e. an adverse selection spiral. However, this concept is difficult to reconcile with the successful operation of many insurance markets, even in the presence of some restrictions on risk classification by regulators.

Moreover, arguably from society's viewpoint, the high risks are those who most need insurance. That is, if the social purpose of insurance is to compensate the population's losses, then insuring high risks contributes more to this purpose than insuring low risks. Thus, the traditional insurers' risk classification scheme can be considered as contrary to this social purpose.

To highlight this issue, [1][2] introduced the concept "loss coverage", i.e. the proportion of the whole population's expected losses which is compensated by insurance. The main idea is that a modest degree of adverse selection in insurance can be desirable, as long as loss coverage is increased.

In this talk we investigate equilibrium in an insurance market where risk classification is restricted. Insurance demand is characterised by an iso-elastic demand function with a single elasticity parameter. We characterise the equilibrium by three quantities: equilibrium premium, level of adverse selection and

loss coverage. We derive conditions for a unique equilibrium, which is assured for plausible population structures and elasticity parameter values. As demand elasticity increases, equilibrium premium and adverse selection increase monotonically, but loss coverage first increases and then decreases. We argue that loss coverage represents the efficacy of insurance for the whole population; and therefore that if demand elasticity is sufficiently low, adverse selection is not always a bad thing: a tolerable degree of adverse selection can increase the level of loss coverage.

References

1. Thomas, R.G.: Loss Coverage as a Public Policy Objective for Risk Classification Schemes. *The Journal of Risk and Insurance* **75(4)** (2008) 997-1018.
2. Thomas, R.G.: Demand Elasticity, Adverse Selection and Loss Coverage: When Can Community Rating Work? *ASTIN Bulletin* **39(2)** (2009) 403-428.

The relationship between risk-neutral and actual default probabilities: the credit risk premium

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J.E.L. classification: G12, G13, G28.

Abstract

The relationship between the risk-neutral measure $\mathbb{Q}$ and the actual or real-world measure $\mathbb{P}$, and the corresponding credit risk premium, are empirically investigated in this paper. We study the ratio between the risk-neutral and actual default intensities ($\frac{\lambda^{\mathbb{Q}}}{\lambda^{\mathbb{P}}}$), which we call the coverage ratio (μ) or the relative risk premium.

Actual intensities ($\lambda^{\mathbb{P}}$) are derived from rating agencies' annual transition matrices applying a heterogeneous Markov chain. The risk-neutral default intensities ($\lambda^{\mathbb{Q}}$) are bootstrapped from single name daily CDS quotes of around 550 European corporates by adopting a simplified version of the standard CDS pricing model.

We quantify the long-term average risk premium and its changes over time. Special attention is given to the recent financial crises and our study allows us to measure its impact on credit risk premia. We find that the post-crisis levels are still higher than those observed before the financial crisis and this is particularly true for high quality debt. If this effect persists, it will have an impact on corporates' funding costs.

In contrast to the previous literature our study specifically focuses on the EU and covers the financial and sovereign crises. The quantification and revision of risk premia contributes to the discussion of the credit spread puzzle [1] and could give extra insights in valuation models that start from real-world estimates.

The work is furthermore relevant in the context of state aid assessment. The European Commission introduced the principle of *Real Economic Value (REV)* in the Impaired Asset Communication [2] to limit market distortions peculiar

to state aid. The REV of a portfolio of impaired assets is the value which takes into account a long-term average risk premium and is the maximum price of a transfer to a bad bank or the maximum state guarantee of a portfolio of impaired assets according to EU regulations [3].

References

1. Amato, J., Remolona, E.M.: *The Credit Spread Puzzle*. BIS Quarterly Review, December (2003).
2. O.J.C: *Communication from the Commission on the treatment of impaired assets in the Community banking sector*. Official Journal of the European Union, C 072, (2009).
3. Boudghene, Y., Maes, S.: *Relieving Banks from Toxic or Impaired Assets: The EU State Aid Policy Framework*. Journal of European Competition Law & practice, (2012).

Robust pricing of fixed income securities*

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J.E.L. classification: C61, G11, G12.

Abstract

We analyze a dynamic investment problem with ambiguity (Problem 1). The financial market constitutes of a money market account, N constant maturity bond funds with different maturities, and a stock market index. The short rate is driven by N factors, and it behaves according to an N-factor Vašiček-model. The stock market index follows a geometric Brownian motion, which can be correlated with the above-mentioned N factors. The investor derives utility from terminal wealth. Although she has a physical probability measure in mind which she considers to be the most likely (called the *base measure*, denoted by $\mathbb{B}$), she is uncertain about it. Thus, she considers other probability measures as well (called *alternative measures*, denoted by $\mathbb{U}$). She chooses the worst case scenario, i.e., she chooses a measure $\mathbb{U}$ which minimizes her value function. Then using this $\mathbb{U}$ measure, she selects the investment policy which maximizes her value function.

After deriving the optimal terminal wealth, the optimal probability measure and the optimal investment policy, we expand our model into a robust general equilibrium model and calibrate it to U.S. market data using the Kalman-filter and the Maximum Likelihood Estimation method. We find that excess returns on long-term bonds are unreasonably high - or putting it another way, we need an unreasonably high relative risk-aversion parameter to explain the excess returns on long-term bonds. This is known in the literature as the *bond premium puzzle*, and is documented in, among others, [1], [2] [4], and [5].

Our paper has three findings. First, our model explains more than 60% of the bond premium puzzle (Table 1). Second, we show that a robust dynamic investment problem effectively increases the subjective discount factor of the investor and makes it a deterministic function of time. And third: we provide an alternative technique to solve robust dynamic investment problems: the robust version of the martingale method.

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Problem 1. Given initial wealth x, find an optimal pair $(X_T, \mathbb{U})$ for the robust utility maximization problem

$$V_0 \triangleq \inf_{\mathbb{U}} \sup_{X_T} E^{\mathbb{U}} \left\{ e^{-\delta T} \frac{X_T^{1-\gamma}}{1-\gamma} + \int_0^T \Upsilon_s e^{-\delta s} \frac{\partial E^{\mathbb{U}} \left[\log \left(\frac{d\mathbb{U}}{d\mathbb{B}} \right)_s \right]}{\partial s} ds \right\} \tag{1}$$

subject to the budget constraint

$$E^{\mathbb{Q}} \left[e^{-\int_0^T r_s ds} X_T \right] = x, \tag{2}$$

where V_t is the investor's value function at time t, δ is her subjective discount factor, T is her investment horizon, X_T is her terminal wealth, γ is her relative risk-aversion parameter, Υ_s is defined (following [3]) as $\Upsilon_s \triangleq \frac{e^{\delta s}(1-\gamma)V_s}{\theta}$ with θ being a the investor's uncertainty-aversion parameter.

Table 1. Calibrated $\gamma + \theta$ (risk-aversion + uncertainty-aversion) values and their disentangled γ and θ components. The bond market consists of two fixed income bond funds with maturities $\tau_1 = 3$, $\tau_2 = 12.55$. The exogenous supply of the stock market index, the two constant maturity bond index funds and the money market account (relative to the wealth of the economy) are $\pi^*_S = 0.6711$, $\pi^*_{B_{\tau_1}} = 0.1393$, $\pi^*_{B_{\tau_2}} = 0.0968$ and $\pi^*_{MMA} = 0.0929$. The detection error probability used for disentangling γ and θ is 10%. The "non-puzzle" level of the relative risk-aversion parameter is set to 5.

$T-t$	$\gamma+\theta$	γ	θ	Explained bond premium puzzle
11	1395.52	603.62	791.90	56.95%
15	71.92	31.11	40.81	60.98%
20	30.80	13.36	17.44	67.60%
30	23.93	10.45	13.48	71.21%
50	18.69	8.22	10.47	76.48%
100	17.39	7.67	9.72	78.45%
∞	17.34	7.65	9.69	78.53%

References

1. Backus, D., Gregory, A., Zin, S.: Risk Premiums in the Term Structure. *Journal of Monetary Economics* **24** (1989) 371-399.
2. van Binsbergen, J.H., Fernández-Villaverde, J., Koijen, R.S.J., Rubio-Ramírez, J.: The term structure of interest rates in a DSGE model with recursive preferences. *Journal of Monetary Economics*, **59** (2012) 634-648.
3. Maenhout, P.J.: Robust Portfolio Rules and Asset Pricing. *The Review of Financial Studies* **17** (2004) 951-983.
4. Piazzesi, M., Schneider, M.: Equilibrium Yield-Curves. In: Acemoglu, D., Rogoff, K. (eds.): *NBER Macroeconomics Annual 2006*, Vol. XXI. MIT Press, Cambridge (2007) 389-472.
5. Rudebusch, G.D., Swanson, E.T.: Examining the bond premium puzzle with a DSGE model. *Journal of Monetary Economics* **55** (2008) S111-S126.

Modelling share prices via the random walk on the Lamplighter group

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J.E.L. classification: G13, G19.

Abstract

The research is a continuation of the study in [6]. It is based on the analysis of randomly selected share prices with the relatively small data size (around 250 closing prices of randomly chosen shares).

Unfortunately, traditional models such as (i) Brownian motion, (ii) random walks with iid increments, (iii) geometric Brownian motion, (iv) geometric Levy processes and geometric random walks , (v) continuous time homogeneous Markov Chain pricing models do not fit our data.

The embedding of the discrete time Markov chains to the continuous time Markov chains seems to be even a bigger problem than the independence assumption. Remind that the embedding problem is to solve the log matrix problem, i.e. to find the Q matrix such that the stochastic matrix P has a representation $P = e^Q$ (see [4] etc. for the embedding problem and its connection with the financial data).

Due to the fact that interest rates are practically zero, it became increasingly popular to use random walks as a modelling tool of risky assets.

Random walks on wreath products are known in the literature as lamplighter random walks, because of the intuitive interpretation of such walks in terms of configuration of lamps (as defined in [7]). To give you a brief explanation of the lamplighter group, imagine a Lamplighter at the position of the marker. He moves around, and when he moves he changes the state of lamp from on to off and the other way around as illustrated in[5].

Motivated by the nature of share prices, we discuss several procedures to model risky assets via the random walk on the lamplighter group (or its tensor products).

Specifically, we model data as a geometric Markov chain with a hidden random walk on group ([3]). The hidden random walk is constructed on the lamplighter group on on $Z(3)$ and on tensor product of groups $Z(2) \oplus Z(2)$. The Lamplighter group has a specific structure where the hidden information is actually explicit. We assume that the positions of lamplighters are known, but we do not know the status of the lamplighters. We refer to it as a hidden random walk on the Lamplighter group.

Choosing the semigroup generators for the branching random walk requires tedious calculations and is still an open question for future research ([1]). To analyse the sensitivity of generators, we choose at least two different generator sets.

We also apply the biased random walks on the tensor product of the Lamplighter group models (as introduced [5]) to compare with the real data. Overall several branching walk models are considered. In addition to the simple branching tree random walk on the group, α-biased random walk on the group, λ-biased random walk on the group and $\alpha - \lambda$-biased random walk with chosen parameters α and λ on the group to model the data. The Monte Carlo simulation is then applied to find the best fit. The results are also compared with analytic errors computed for the relative distance between two tensor products of random stochastic matrices.

The tensor product structure comes from the split of the data into "no jump", "small jump" and "no big jump" groups and matching into the "no small jump-small jump" and "no big jump-big jump" groups. This then requires to deal with the missing data, which is treated by several methods such as Expectation-Maximization algorithm ([2]) algorithm with incorporated MCMC elements.

The fit is relatively good. Moreover, for the randomly chosen data sets, the α-biased random walk on the tensor product of the lamplighter group and $\alpha - \lambda$-biased random walk provide significantly better fit to the data comparing with other models.

References

1. F.K. Chung, R.L. Graham: *Random walks on generating sets for finite groups*, Electronic Journals of Combinatorics, (1997), 4, 14-28.
2. A.P. Dempster, N.M. Laird, N.M. and D.B. Rubin: *Maximum Likelihood for Incomplete Data via the EM Algorithm*, Journal of the Royal Statistical Society, (1977), Series B, 39, 1-38.
3. Y. Guedon: *Estimating hidden semi-Markov chains from discrete sequences*, Journal of computational and graohical statistics, (2003),12, 604-639.
4. R. Israel, J.S. Rosenthal and J.Z. Wei : *Finding generators for Markov chains via empirical transition matrices, with applications to credit ratings*, Mathematical Finance, (1999) vol.11, pp.245265.
5. R. Lyons, R. Pemantle, Y. Peres: *Random walks on the lamplighter group*, The annals of probability, (1996) Vol.24, No.4, pp 1993-2006.
6. X. Ma, S. Utev: *Modelling the share prices as a hidden random walk on the lamplighter group*, Mathematical and Statistical Methods for Actuarial, (2012) Springer.
7. N. Varopoulos: *Random walks on solvable groups*, Bull. Sci. math., 2eme serie 107 (1983), 337344.

Optimal portfolios with downside risk*

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J.E.L. classification: C61.

Abstract

Markowitz optimal portfolio theory, also known as the Mean-Variance theory, has had a tremendous impact and hundreds of papers are devoted to this topic. This theory addresses the question of minimizing risk for a given expected return and an optimal solution is found under one of the two assumptions: the distribution of the portfolio is normal, or the utility function is quadratic. In this theory, investor's decision formulates a trade-off between the return and the risk, in which the risk is measured by the variance of the returns.

However, it has also been noted numerously in the past, starting with Markowitz himself, that the investors are more concerned with downside risk, i.e. the possibility of returns falling short of a specified target, rather than the variance, which takes into account both the favorable upside deviations as well as the averse downside parts. Moreover, such classic Mean-Variance framework does not consider investor's individual preferences. Thus, alternatives are proposed in the literature in the form of downside risk measures, such as *target shortfall* and *semivariance*, or more generally, the so-called lower partial moments; see, for example, Harlow [2] and Sawik [3], Cumova and Nawrocki [1].

This article considers downside risk measures $E((X-K)^-)^\beta$, where $\beta = 1, 2$ and $(X-K)^- = \max(0, K-X)$. When vector of stock returns $\mathbf{X}$ has multivariate normal distribution we show that minimization of downside risk for portfolios with pre-specified expected returns leads to the same solution as minimization of the variance. Hence such optimal portfolios are defined by the Markovitz optimal solution.

If the expected returns are not pre-specified, we show that the problem of minimization of downside risk has an analytical solution and we present this solution together with several illustrative numerical examples. We also solve the problem on minimization of mixed downside risks considered here, and provide the numerical illustration of results.

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References

1. Cumova, D., Nawrocki, D.: Portfolio optimization in an upside potential and downside risk framework. *Journal of Economics and Business* **71** (2014) 68-89.
2. Harlow, W.V.: Asset allocation in a downside risk framework. *Financial Analysts Journal* (1991), 28-40.
3. Sawik, B.: Downside risk approach for multi-objective portfolio optimization In: *Operations Research Proceedings* Springer Berlin Heidelberg (2011) 191-196.

Replicating inter-generational risk sharing in financial market*

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J.E.L. classification: H55, J26.

Abstract

Inter-generational risk sharing is often seen as one of the strengths of the Dutch pension system. The ability to absorb financial and actuarial shocks through the funding ratio allows for smoothing of returns over generations. Nevertheless, this implicitly means that generations subsidize each other, which has its disadvantages, especially in the light of incomplete contracts. In this paper, we highlight the advantages of inter-generational risk sharing, as a main characteristic of certain pension plans, and investigate if and how much of this can be replicated in the markets. By using a stylized model based on different pension plans such as "hard" defined benefit, "soft" defined benefit, collective defined contribution and individual investing ("pure" defined contribution), this study concretely identifies the effects of demographic upward and downward shock (*resp.* life-expectancy and fertility rate). We investigate these shock effects on the share of the replication of fund returns by individual investment. Furthermore, we decompose them on the effects related to fund versus individual participation and discuss how heterogeneously they are absorbed by different plans.

We investigate those arguments by modeling a stylized pension contract and considering different pension plan such as the hard DB plan, the conditional DB plan, the DC plan and the CDC plan. The population is based on real Dutch data (CBS), while simulated scenarios for the term structure (Vasicek one-factor model), stock returns (Black and Scholes model), risk-free returns (bank account)

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, price inflation and wage inflation are used for the calculating the pension plans characteristics. A Mincer wage profile is introduced based on the real Dutch wage profile to capture the heterogeneity in contributions of different cohorts at a given moment in time. The introduction of some "policy safety rules" help controlling o some extent the funding ratio and avoid its diverging. The real Dutch surviving probability is proxy by the Gompertz law. The fund participation results are compared to the individual investment conclusions where the only difference is that agents saving individually use an age dependent investment, while the fund keeps the "constant mix" strategy constant.

Although this study remains conducted based on the Dutch economic framework, one could deduce two main policy recommendations. On the one hand, a necessary reform for plans which are still offering "hard" guarantees is needed. Among the collective plans the CDC appears to be the one better amortizing risk and offering sustainability in pension benefits provision. On the other hand, we concluded that it is possible to replicate part of the fund performance by individually investing. What is remained unable to be replicated by the individual investment is characteristic of the pension plan.

References

1. John Ameriks and Stephen P. Zeldes. How do household portfolio shares vary with age? Working paper, Columbia University, 2004.
2. Laurence Ball and N. Gregory Mankiw. Intergenerational risk sharing in the spirit of arrow, debreu, and rawls, with applications to social security design. *Journal of Political Economy*, 115(4):523–547, 2007.
3. F. Black and M. Scholes. The Pricing of Options and Corporate Liabilities. *The Journal of Political Economy*, 81(3):637–654, 1973.
4. D. Broeders and E. H. M. Ponds. Dutch Pension System Reform a Step Closer to the Ideal System Design?! Report 3, CESifo DICE, 2012.
5. J. Cui, F. de Jong, and E. Ponds. Intergenerational risk sharing within funded pension. *Journal of Pension Economics and Finance*, 10(1):1–29, 2008.
6. Peter A. Diamond. A framework for social security analysis. *Journal of Public Economics*, 8:275–298, 1977.
7. Christian Gollier. Intergenerational risk-sharing and risk-taking of a pension fund. *Journal of Public Economics*, 92(5):1463–1485, 2007.
8. R. Gordon and H. Varian. Intergenerational risk sharing. *Journal of Public Economics*, 37(2):185–202, 1988.
9. Zina Lekniute. A value–based approach to pension plan redesign in the netherlands. who will gain and who will lose. Master's thesis, University of Tilburg and APG, 2011.
10. Robert J. Shiller. The life-cycle personal accounts proposal for social security: An evaluation. Working Paper 11300, National Bureau of Economic Research Inc., 2005.
11. Oldrich Vasicek. An Equilibrium Characterization of the Term Structure. *Journal of Financial Economics*, 5(2):177–188, 1977.

q-Credibility

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Abstract

This article extends credibility theory by making quadratic adjustments that take into account the squared values of past observations. This approach amounts to introducing non-linearities in the framework, or to considering higher order cross moments in the computations. We first describe the full parametric approach and, for illustration, we examine the Poisson-gamma and Poisson-single Pareto cases. Then, we look at the non-parametric approach where premiums must be estimated based on data only, without postulating any type of distribution. Finally, we examine the semi-parametric approach where the conditional distribution is Poisson but the unconditional distribution is unknown. The goal of this paper is not to claim that q-credibility always brings better results than standard credibility, but it is to provide several building blocks for understanding how credibility changes when quadratic corrections are added.

The origins of credibility theory can be traced back to the papers of Mowbray (1914), Whitney (1918), Bailey (1945, 1950), Longley-Cook (1962), and Mayerson (1964). The core of the theory, as it is known today, is developed in Bühlmann (1967) and in Bühlmann and Straub (1970). See also Hachemeister (1975) for the link with regressions, Zehnwirth (1977) for the link with Bayesian analysis, and Norberg (1979) for the application to ratemaking. General presentations of the theory can be found in Bühlmann (1970), Herzog (1999), Norberg (2004), Bühlmann and Gisler (2005), Klugman, Panjer, and Willmot (2012).

In this paper, we construct a quadratic credibility framework where premiums are estimated based on the values of past observations and of past squared observations. Indeed, even in classic credibility theory, credibility estimators are not restricted to be linear in the observations. See Bühlmann and Gisler (2005) where a credibility estimator is built as a function of a maximum likelihood estimator computed from the observations, or where a multivariate credibility framework, which can depend for instance on the square of the observations, is set out.

Here, we fully compute non-linear, quadratic, credibility estimators in situations that range from parametric to non-parametric settings. The framework that is developed can be useful for the modeler who explicitly wants to deviate from a linear framework and to explicitly take into account higher order (cross) moments. For instance, our framework makes use of the explicit values of the covariance between observations and squared observations, and also of the covariance between squared observations. For each of the parametric, non-parametric, and semi-parametric settings explored in this paper, we give illustrations of the reduction of the error (as set out in Neuhaus (1985)) gained by going from the classic to the quadratic credibility approach.

The paper is organized as follows. The first section develops a parametric quadratic credibility - or q-credibility - approach and provides illustrations of this approach in the Poisson-gamma and Poisson-single Pareto settings. Building on the results of the first section, the second section derives a non-parametric approach and the third section concentrates on a semi-parametric approach where the conditional distribution is assumed to be of the Poisson type.

References

1. Bailey, A.: A Generalized Theory of Credibility. *Proceedings of the Casualty Actuarial Society* **37** (1945) 13-20.
2. Bailey, A.: Credibility Procedures. *Proceedings of the Casualty Actuarial Society* **37** (1950) 7-23, 94-115.
3. Bühlmann, H.: Experience Rating and Credibility. *ASTIN Bulletin* **4(3)** (1967) 199-207.
4. Bühlmann, H.: *Mathematical Methods in Risk Theory*, Springer, Berlin (1970).
5. Bühlmann, H., Gisler, A.: *A Course in Credibility Theory and its Applications*. Universitext, Springer, Berlin (2005).
6. Bühlmann, H., Straub, E.: Glaubwürdigkeit für Schadensätze (Credibility for Loss Ratios). *Mitteilungen der Vereiningun Schweizerischer Versicherungs - Mathematiker* **70** (1970) 111-133.
7. Hachemeister, C. A.: Credibility for Regression Models with Application to Trend. In: *Credibility: Theory and Applications*, ed. by P. M. Kahn. Academic Press, New York (1975) 129-169.
8. Herzog, T. N.: *Credibility Theory*. ACTEX Publications, Third Edition (1999).
9. Klugman, S. A., Panjer, H. H., Willmot, G. E.: *Loss Models. From Data to Decisions*. Wiley, Fourth Edition (2012).
10. Longley-Cook, L.: An Introduction to Credibility Theory. *Proceedings of the Casualty Actuarial Society* **49** (1962) 194-221.
11. Mayerson, A. L.: The Uses of Credibility in Property Insurance Ratemaking. *Giornale dell'Istituto Italiano degli Attuari* **27** (1964) 197-218.
12. Mowbray, A. H.: How Extensive a Payroll Exposure Is Necessary to Give a Dependable Pure Premium. *Proceedings of the Casualty Actuarial Society* **1** (1914) 24-30.
13. Neuhaus, W.: Choice of Statistics in Linear Bayes Estimation, *Scandinavian Actuarial Journal* (1985) 1-26.
14. Norberg, R.: The Credibility Approach to Ratemaking. *Scandinavian Actuarial Journal* (1979) 181-221.
15. Norberg, R.: Credibility Theory. *Encyclopedia of Actuarial Science*, Wiley (2004).
16. Whitney, A. W.: The Theory of Experience Rating. *Proceedings of the Casualty Actuarial Society* **4** (1918) 274-292.
17. Zehnwirth, B.: The Mean Credibility Formula Is a Bayes Rule. *Scandinavian Actuarial Journal* (1977) 212-216.

Natural hedging in long term care insurance

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Abstract

Disability insurance has reached a global relevance due to the increased number of elderly in the world, which generate a higher demand for long term care (LTC) services. In fact, most of the LTC recipients are over 65 years of age and around 60% are women because of their higher life expectancy combined with a higher prevalence of disability in old age (OECD [2]). Consequently, public expenditure on LTC continues to grow significantly, weighing on government budgets and debt levels in developed countries.

In Italy, public LTC benefits and services are provided by Institutions of different nature and structure, i.e. the Municipalities, Local Health Authorities, Nursing homes and the National Institute of Social Security (Istituto Nazionale Previdenza Sociale, INPS). Thus, the funding and the management of LTC services are spread over local, regional and central State authorities, with different principles and eligibility criteria fixed in the institutional models of each Region. Where the public provision of care services is partial, fragmented (as in Italy) or not available, care is mostly financed out-of-pocket. In this context, private LTC insurance can play an important role, providing solutions integrated with the governments and health care institutions services.

From a technical point of view, disability benefits are affected by biometric risks (longevity and disability risks). While longevity risk has been widely and accurately defined in the insurance literature, the same cannot be said for disability risk. In the Solvency II Directive the latter is described as the risk of adverse changes in the value of insurance liabilities, resulting from changes in the level, trend or volatility of disability rates. Both of these risks are systematic as they arise from the uncertainty of future development of mortality and disability rates and expose the insurance companies selling disability insurance to potential unexpected losses.

Insurers can use different approaches to protect themselves from the effect of biometric risks: they can internally reduce the risk exposure using stochastic mortality forecasting models and natural hedging or decide to partially transfer

the risk through tradition reinsurance or via mortality-linked securities traded on the financial market. However, mortality-linked securitization only covers longevity risk, while there are not specific tools for disability risk.

Our paper focuses on the application of natural hedging for insurers selling disability benefits by examining the advantages of portfolio diversification, which is essential for the purposes of both risk management and the calculation of solvency capital requirements for longevity and disability risks under Solvency II. Natural hedging of disability insurance is obtained by diversifying both longevity and disability risks through a suitable mix of insurance benefits within a policy or a portfolio. The main advantages of a natural hedging approach are that it does not require the insurer to find counterparties, there are no transaction costs and that it is an internal tool for insurers to diversify biometric risks.

The literature on this topic shows that natural hedging can considerably reduce the sensitivity of an insurance portfolio against longevity risk. See, e.g., Cox and Lin [1] that introduced natural hedging for the mortality risk management, Tsai et al. [4] that proposes a conditional value-at-risk minimization approach to obtain an optimal product mix for insurance companies who want to hedge against systematic mortality risk; and Wang et al. [5] that propose an immunization model to calculate the optimal life insurance-annuity product mix ratio to hedge against longevity risk.

We extend the existing literature on natural hedging of longevity risk to disability risk to create a perfect hedge for LTC insurers. To this purpose, we define a multivariate duration based on the transition rates underlying the multiple state model that describe the insurance benefits. The idea of a multivariate duration has been proposed in Reitano [3] to study the interest rate sensitivity of the price of a portfolio of assets and liabilities, when the yield curve shifts are multivariate. In our paper, this concept is widened to the case of a LTC portfolio where the liabilities are sensitive to the changes of mortality and disability transition rates. According to the multivariate duration, we propose an immunization model in a stochastic environment that combine disability and life benefits in an optimal proportion.

References

1. Cox, S. H., Lin, Y.: Natural Hedging of Life and Annuity Mortality Risks. *North American Actuarial Journal* **11** (2007) 1-15.
2. OECD.: Recipients of long-term care. In Health at a Glance 2013: OECD Indicators, OECD Publishing (2013).
3. Reitano, R. R.: Multivariate duration analysis. *Transactions of the Society of Actuaries*, **XLIII** (1991) 335-391.
4. Tsai, J. T., Wang, J. L. and Tzeng, L. Y.: On the Optimal Product Mix in Life Insurance Companies Using Conditional Value at Risk. *Insurance: Mathematics and Economics* **46** (2010) 235-241.
5. Wang, J.L., Huang, H.C., Yang, S.S., Tsai, J.T.: An optimal product mix for hedging longevity risk in life insurance companies: the immunization theory approach. *Journal of Risk and Insurance* **77** (2009) 473-497.

Truncated realized covariance when prices have infinite variation jumps*

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Abstract

The speed of convergence of the Truncated Realized Covariance (TRC) to the Integrated Covariation between the Brownian parts of two semimartingales is heavily influenced by the presence of infinite activity jumps with infinite variation (iV), through both the degree of dependence and the jump activity indices of the two small jumps processes. The estimator is efficient in some cases of iV jumps.

The result of this paper is relevant in financial economics, since by the TRC it is possible to separately estimate the common jumps among two assets, which has important implications in risk management and contagion modeling.

We consider two state variables evolving as follows

$$dX_t^{(q)} = a_t^{(q)}dt + \sigma_t^{(q)}dW_t^{(q)} + dZ_t^{(q)}, \quad q = 1,2, \quad t \in [0,T] \tag{1}$$

with T fixed, where $W^{(1)}$ and $W^{(2)}$ are dependent Wiener processes with instantaneous correlation coefficient ρ_t for any $t \in [0,T]$, and $Z^{(1)}$ and $Z^{(2)}$ are correlated pure jump semimartingales (SMs). Given discrete equally spaced observations $X_{t_i}^{(1)}, X_{t_i}^{(2)},\ i = 1..n$, in the interval $[0,T]$, with $t_i = ih, h = \frac{T}{n}$, it is possible to identify the *Integrated Covariation* $IC := \int_0^T \rho_t \sigma_t^{(1)} \sigma_t^{(2)} dt$. As the observation step h tends to 0, the *Realized Covariance* $\sum_{i=1}^n \Delta_i X^{(1)} \Delta_i X^{(2)}$, where $\Delta_i X^{(m)} := X_{t_i}^{(m)} - X_{t_{i-1}}^{(m)}$, converges to the global quadratic covariation $[X^{(1)}, X^{(2)}]_T = \int_0^T \rho_t \sigma_t^{(1)} \sigma_t^{(2)} dt + \sum_{0 \le t \le T} \Delta Z_t^{(1)} \Delta Z_t^{(2)}$, where $\Delta Z_t^{(m)} = Z_t^{(m)} - Z_{t-}^{(m)}$, containing also the *co-jumps* $\Delta Z_t^{(1)} \Delta Z_t^{(2)}$. However the *Truncated Realized Covariance*,

$$\hat{IC} = \sum_{i=1}^n \Delta_i X^{(1)} I_{\{(\Delta_i X^{(1)})^2 \le r_h\}} \Delta_i X^{(2)} I_{\{(\Delta_i X^{(2)})^2 \le r_h\}},$$

with a properly chosen deterministic function r_h, e.g. $r_h = h^{2u}$ with $u \in (0, 1/2)$, is consistent to IC ([?], [?]). A CLT for $\hat{IC}$ has been established when the jump

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* Supported by EIF and GNAMPA.

activity of the processes is relatively moderate, namely, either when (as in [**?**]) the jumps have *finite activity* (FA), i.e. only finitely many jumps can occur, along each path, in each finite time interval, or when (as in [**?**], Thm 7.4) the jumps have infinite activity (IA) but *finite variation* (FV), i.e. $\sum_{s\le T} |\Delta X_s^{(m)}| < \infty$ a.s., for both $m = 1, 2$. In such cases the estimation error is asymptotically mixed Gaussian and converges at rate (or speed) $\sqrt{n}$.

Here we find the rate of convergence of $\hat{IC}$ in the case where at least one jump component has iV, and we show that the small jumps play a crucial role. The small jumps of each SM are assumed to be the small jumps of a Lévy stable process, with stability indices α_1, α_2 such that $\alpha_1 \le \alpha_2$ and $\alpha_2 \ge 1$. Further, a simple dependence structure is imposed to the two stable processes: the dependence degree is measured by a parameter, $\gamma \in [0,1]$, and can range from complete dependence ($\gamma = 0$) to independence ($\gamma = 1$). The result is that when the small jumps are dependent ($\gamma \in [0,1)$), then the estimation error $\hat{IC} - IC$ tends to zero as: $\sqrt{h}$, when α_1 is small and α_2 is close to 1; $(1-\gamma) r_h^{1+\alpha_2/\alpha_1-\alpha_2}$, if either α_1 is a bit larger but still α_2 is close to 1 or they are both large and very close; $h r_h^{-\alpha_2}$, when α_2 is large and strictly larger than α_1. When the small jumps are independent then the behavior is only determined by α_2.

A comparison of the rate of $\hat{IC}$ with the rates $\rho_n, \sqrt{n}$ of the univariate estimators in [**?**] and in [**?**] shows that in some cases $\hat{IC}$ is the most efficient estimator.

Estimation of IC is of strong interest both in financial econometrics (see e.g. [**?**]) and for portfolio risk and hedge funds management ([**?**]), in particular $[X^{(1)}, X^{(2)}] - \hat{IC}$ gives a tool for measuring the propagation among assets of effects due to important negative or positive economic events. Knowledge of the convergence rate helps in assessing the reliability of the estimator on finite samples.

References

1. Andersen, T., Bollerslev, T., Diebold, F.: Roughing it up: Including jump components in the measurement, modeling and forecasting of return volatility. The Review of Economics and Statistics, 89(4), 701-720 (2007)
2. Cont, R., Tankov, P.: Financial Modelling with Jump Processes. CRC Press (2004)
3. Jacod, J.: Asymptotic properties of realized power variations and associated functions of semimartingales. Stochastic Processes and Their Applications, 118, 517-559 (2008)
4. Jacod, J.: Statistics and high-frequency data. In: M. Kessler, A. L., Sorensen, M. (eds.): Statistical Methods for Stochastic Differential Equations. Chapman and Hall/CRC (2012)
5. Jacod, J., Reiss, M.: A remark on the rates of convergence for integrated volatility estimation in the presence of jumps. Annals of Statistics, 42(3), 1131-1144 (2014)
6. Jacod, J., Todorov, V.: Efficient Estimation of Integrated Volatility in Presence of Infinite Variation Jumps. Annals of Statistics, 42, 1029-1069 (2014)
7. Mancini, C., Gobbi, F.: Identifying the Brownian covariation from the co-jumps given discrete observations. Econometric Theory, 28(2), 249-273 (2006)

Sovereign ratings implied by coupled CDS-bond market data

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J.E.L. classification: G24, C44, C55.

Abstract

Market implied ratings are a tool used by financial institutions to infer from the market *early warnings* about future upgrades and downgrades of Agency Ratings. The idea is really simple: since Rating Agencies are physiologically slow in officially claiming rating changes, one could try to use the market as a source of higher frequency information in order to predict future rating changes.

Indeed, in the market you can find products that pertain precisely to the credit risk of an agent, namely Credit Default Swaps, whose market, born around 2000, has seen a rapid growth since its beginning. CDS spreads should, in principle, contain exactly the information about the Probability of Default of the target institution and thus their market value should reflect the credit rating of that target.

In the literature you can find some studies that try to attack this problem: how to infer credit ratings from CDS quotes. In particular, the 'Big Three' agencies, namely Moody's, Standard & Poor's and Fitch, have published reports on the methodology they use to infer their market based *early warnings* [2–4]. In the paper [6] we dwell in particular on one methodology, which we call Kou-Varotto since its definitive explanation was given in [1], which is actually implemented by Fitch, even if in a slightly different version [2].

Our proposal is to extend Kou-Varotto model in order to use a 2-dimensional input: instead of inferring ratings from CDS only, we build a model that infers rating from CDS and bonds. We do it for the sovereign rating sector alone. The idea is motivated by the fact that, while in the corporate sector the information embedded in CDS and bonds can be seen to be pretty much the same (namely, the two are highly correlated) in the sovereign sector this is not always the case:

CDS spreads could be rising for all the countries in a period of turmoil while bond spreads of countries perceived as the more stable ones would rather be decreasing. This has been the case of Germany, during the Eurozone crisis of 2010-2011.

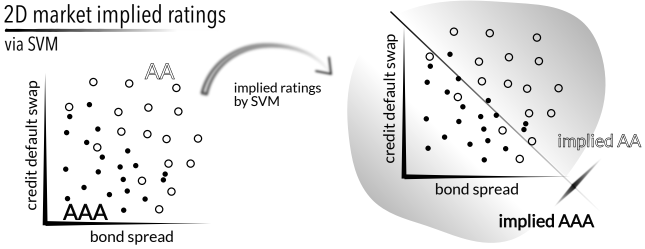

Fig. 1. 2-dimensional implied ratings

In order to build a 2-dimensional model we could no more rely on the simple methods described in [1] and we implemented a Machine Learning algorithm (Support Vector Machines) [5] to divide the points on the CDS-bond plane into regions of implied ratings, as sketched in figure 1.

We perform the calculation on a panel of 36 countries on an interval of 10 years and we compare our results with the (1-dimensional) CDS Kou-Varotto model. The accuracy of prediction is really good both for our model and for the 1-dimensional one, but, on average, our model performs better. Unfortunately, statistical samples for sovereign ratings are always rather poor, since downgrades, upgrades and defaults are not so numerous and drawing strong conclusions from statistics becomes difficult. However, the methodology used can be very well generalized to include more (and/or different) dimensions and can be used and tested on the corporate sector, where statistics is much more robust.

References

1. Kou, J., Varotto, S.: Timeliness of spread implied ratings. *European Financial Management* **14** (2008) 503-527.
2. Gupton, G., Kocagil, A.E., Reyngold, A.: Fitch CDS Implied Ratings. (CDS-IR) model. *Technical report* Fitch, Inc (2007).
3. Gibbon, J. et al.: Moody's Market Implied Ratings: Description, methodology, and analytical applications. *Technical report* Moody's Investors Service (2007).
4. Bergman, S. et al.: How Standard and Poor's arrives at Market Derived Signals. *Technical report* Standard and Poor's (2009).
5. Hastie, T., Tibshirani, R., Friedman, J.: *Element of Statistical Learning*. Springer (2009).
6. Marmi, S., Nassigh, A., Regoli, D.: Sovereign ratings implied by coupled CDS-bond market data. *Preprint*, available on SSRN (2014).

On the adequate funding ratio in occupational pension funds from the insured's perspective

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J.E.L. classification: J32, H55, G22.

Abstract

The demographic and capital market framework conditions for occupational pension funds have significantly changed over the last decades. A declining ratio of the number of active workers to the number of retirees[1] and historically low returns accompanied with higher volatility pose challenges to pension funds. Furthermore, the social environment is seeing changes as individuals are more mobile, change their jobs more often and therefore require individualized pension plans. This is accompanied by a more complex legislation which increases the complexity and hence the costs. In many countries reforms have been strongly rejected in the last years and the definitions of technical and actuarial parameters are contingent on political processes.

The aim of this paper is to discuss and evaluate the adequate asset-liability funding ratio for pension funds under consideration of demographic trends and capital market risks from the viewpoints of the different stakeholders[2, 3]. To this regard, the policyholder participation and surplus distribution mechanisms in the case of high funding ratios and supplemental contribution mechanisms in the case of too low funding ratios are of particular relevance. For both, bonus distribution and additional contributions, there exist several methods in order to calculate the amounts that are to be paid.

Due to the plethora of calculation methods and many more possible boundaries for triggering those, there is a great variety of pension scheme frameworks. Comparing them with each other with regard to the highest customer utility while maintaining a certain safety level is the main goal of our research.

In order to properly control for actuarial gains and losses over time, a scenario based stochastic approach seems natural[4]. By performing numerical simulations, we examine how the accounts of policyholders evolve over time. We take a simplified balance sheet approach and model a pension fund by simulating the assets A and the liabilities L of the fund. Going more into detail, we also look at predetermined market scenarios, e.g. Japan-style scenarios. This way, it is to be examined if the pension fund models can persist over a longer period in an extreme market environment[5].

Another important aspect lies in the change of pension funds. It needs to be decided to what extend new customers should participate, both, in bonus payments as well as in additional contributions.

At the end of the considered time frame, the total value of all insured accounts, a stochastic outcome, is calculated. Applying internal rate of return calculations and suitable preference functions, the associated utility of the policyholders is derived[6]. Performing analyzes in order to compare the effect of various mechanisms and thresholds, optimal values for the model parameters and the funding ratio are derived. Sensitivity analyzes on the various models allow to examine the robustness of the results.

In the numerical analysis, we first study the impact of the various model parameters. We conclude that the initial capital does not have an influence on the funding ratio and the expected customer utility at retirement. In a second step, we derive optimal bounds for the funding ratio for selected types of customers.

With the modeling approach and the research question about the optimal funding ratio we extend the existing literature on pension funds. The idea can also be applied within an enlarged international scope to the funding levels of pension schemes in other countries. For individual pension funds, our findings may lay the basis for developing funding and distribution mechanisms within their framework conditions that lead to better outcomes for their customers. Fair and transparent mechanisms may also grow the acceptance of funding rules in the policyholder collective and diminish injustice in a social system which is currently under stress due to lower returns from and higher volatility in capital markets. The expected results are threefold:

- A conceptual model for assessing advantages and drawbacks, in particular wealth transfers among insureds.
- Empirical findings for the guidance and definition of rules for governance.
- Quantification of the impact of different management actions.

References

1. OECD, 2013, Pensions at a Glance 2013: OECD and G20 Indicators, Technical Report.
2. Braun, A., Rymaszewski, P., Schmeiser, H.: A Traffic Light Approach to Solvency Measurement of Swiss Occupational Pension Funds. *The Geneva Papers on Risk and Insurance - Issues and Practice* **2** (2011) 254-282.
3. Credit Suisse Economic Research, 2014, Schweizer Pensionskassen 2014: Perspektiven in der Demografie und im Anlagemanagement. Technical Report.
4. Broeders, D., Chen, A.: Pension Benefit Security: A Comparison of Solvency Requirements, a Pension Guarantee Fund, and Sponsor Support. *The Journal of Risk and Insurance* **2** (2013) 239-272.
5. Berdin, E., Gründl, H.: The Effects of a Low Interest Rate Environment on Life Insurers. *The Geneva Papers on Risk and Insurance - Issues and Practice* **4** (2015) 385-415.
6. Schmeiser, H., Wagner, J.: A Proposal on How the Regulator Should Set Minimum Interest Rate Guarantees in Participating Life Insurance Contracts. *The Journal of Risk and Insurance* **3** (2014) 659-686.

Cover call writing and framing: a cumulative prospect theory approach

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Abstract

The covered call writing (CC) is a popular strategy, used both by experienced investors and non-professional traders who are not so familiar with derivatives. The seller of the call option owns the underlying asset and her/his risk is limited, but this is not sufficient to explain the success of such a strategy amongst investors, or the preference for CC despite several alternative and less known strategies with similar profit profiles, which register significantly lower trading volume. Using modern prospect theory (PT) arguments, we are able to analyze some aspects that characterize the behavior and choices of the decision makers. Shefrin and Statman [4] were the first to suggest hedonic framing [5] and risk aversion in the domain of gains as main reasons for departure from standard financial theory: writers of CC prefer this strategy to a stock only position and are loath to repurchase the call when this entails a realization of a loss, out-of-the money calls are preferred to in-the-money calls in the strategy, fully covered positions are preferred to partially covered ones, CC is preferred to other strategies such as naked puts. Recently, Hoffmann and Fischer [3] test empirically all these hypothesis. In this contribution, we extend the analysis considering CC in a cumulative prospect theory (CPT) framework [6] in its continuous version [1].

According to CPT, risk attitude, loss aversion and probability perception are described by two functions: a value function v and a weighting function w; decision weights are differences in transformed cumulative probabilities of gains or losses. Specific parametric forms have been suggested in the literature; the shape of these functions becomes significant in describing actual investors behaviors. The function v is typically convex in the range of losses and concave in the range of gains, it is steeper for losses. Subjective probabilities may be evaluated through different weighting functions: w^- for losses and w^+ for gains, respectively. Decision makers have biased probability estimates: they tend to underweight high probabilities and overweight low probabilities.

[4] consider the CC strategy in a simple one period binomial model under PT in its original version; they use only a value function and do not consider probability weighting, and assume a zero risk-free interest rate. When we consider the problem under continuous CPT, the prospect value of the stock-only

position is

$$\begin{aligned} V^s = &\int_0^{S_0 e^{rT}} \psi^-(F(x))f(x)v^-(x - S_0 e^{rT})dx + \\ &+ \int_{S_0 e^{rT}}^{+\infty} \psi^+(1 - F(x))f(x)v^+(x - S_0 e^{rT})dx \,, \end{aligned} \tag{1}$$

where $S_0 > 0$ is the current stock price, ψ is the derivative of the weighting function w with respect to the probability variable, F is the cumulative distribution function and f is the probability density function of the underlying price at maturity S_T. Assume an out-of-the-money call option written on the same stock, with strike price X (with $S_0 e^{rT} < X$) and maturity T. Let c be the option premium. The prospect value of a CC position, when the option premium and the CC result are segregated into two mental accounts, is given by

$$\begin{aligned} V^{cc} = v^+(c\, e^{rT}) + &\int_0^{S_0 e^{rT}} \psi^-(F(x))f(x)v^-(x - S_0 e^{rT})dx + \\ &+ \int_{S_0 e^{rT}}^{X} \psi^+(1 - F(x))f(x)v^+(x - S_0 e^{rT})dx + \\ &+ \int_{X}^{+\infty} \psi^+(1 - F(x))f(x)v^+(X - S_0 e^{rT})dx \,. \end{aligned} \tag{2}$$

Shefrin and Statman argue that “the PT expected value of the covered call position exceeds the PT value of the stock-only position for investors who are sufficiently risk-averse in the domain of gains”. This hypothesis seems not be confirmed by [3], whereas the authors find strong evidence for framing effects. [2] argue that a PT investor with above average risk aversion for gains prefers the CC. In this work, we test this and other hypothesis considering the effects of both the value and weighting functions parameters, and different framing.

References

1. Davies, G.B., Satchell, S.E.: The behavioural components of risk aversion. *Journal of Mathematical Psychology* **51(1)** (2007) 1–13.
2. de Groot, J.S., Dijkstra, T.K.: *Writing covered calls: Should be done?* Gröninger SOM Research School, SOM Research Reports Series (1996).
3. Hoffmann, A.O.I., Fischer, E.T.: Behavioral aspects of covered call writing: an empirical investigation. *Journal of Behavioral Finance* **13** (2012) 66-79.
4. Shefrin, H., Statman, M.: Behavioral aspects of the design and marketing of financial products. *Financial Management* **22** (1993) 123-134.
5. Thaler, R.H.: Mental accounting and consumer choice. *Marketing Science*, Summer (1985) 199-214.
6. Tversky, A., Kahneman, D.: Advances in prospect theory: cumulative representation of the uncertainty. *Journal of Risk and Uncertainty* **5** (1992) 297-323.

Explorations in the use of artificial intelligence techniques and econometric forecasting in the €-$ market

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J.E.L. classification: C22, C45, C88, G17.

Abstract

The research and practice area of this paper is day trading in the foreign exchange market, meaning that all trades must be closed by the end of the day. The approach taken in the paper is different from high frequency trading, with many trades done in the day, widely used in the trading world today. Our system allows for a maximum of three trades in the twenty four hours.

Another important difference between our approach and the mainstream approach to short-term trading refers to the long-short decision methodology used in our approach. The standard approach is based on various form of technical analysis, with chart or breakout methodologies [?].

Our approach uses a small econometric 8-hour frequency model to take the long-short opening decision. The closing decision (Stop-loss, SL, and Take-profit, TP) is taken by using two Artificial Intelligence-Inspired (AII) protocols [?], [?], [?].

The specification of the model is driven mostly by scheduled (macroeconomic data with a release timing well known in advance) and unscheduled (unexpected) market and policy news relevant for the €-$ currency pair [?], [?], [?].

In the specification of the model there are also other structural variables, considered to be standard in the financial literature: interest rate differentials, stock index dynamics and lagged dependent variables.

The 8-hour frequency is necessary to assess carefully the impact of news in the relevant trading area (Asian, European, American) and evaluate correctly the spillover into subsequent trading areas.

Our current research strategy for day-trade the €-$ - proposed for the MAF2016 Conference -uses a short-term GARCH multi-equation model estimated between 1999 and 2007 (still unpublished, but presented in various seminars, included a Venice MAF meeting [?]) in order to issue Long/Short trading signals for €-$ day-trading, based on its appreciation/depreciation forecasts.

Optimal stopping parameters, i.e. SL and TP, are determined by two AII techniques: a data-mining version of a Genetic Algorithm (GA) and a combination of a Fuzzy Logic Controller and a Neural Network, FLC-NN.

Optimality is here meant to be getting the highest trading profit consistent with the smallest number of trading Drawdowns (DD). The two AII methods are employed to reach this goal. They are trained (in a Training Set, TNS) for 750 trading days, between 2008 and 2010. The optimal parameters are then used in Testing (or Trading, TRS) mode for 782 days, between 2011 and 2013. This is the experimental layout at this moment.

The combination of econometric forecasting and AII (to find optimal stopping rules) yields a trade-off locus between profits and drawdown (DD) of the expected positive slope: the higher the profits, the higher the DD.

The results, obtained so far, indicate a far superior performance of the two AII-optimized rules with respect of a Buy & Hold strategy. The same holds true also with respect to the use of a set of TP and SL of consensus and 'common sense' among traders.

Our research activity has still an exploratory nature but with positive results on two counts.

Firstly, we have profitable results in using econometric techniques to forecast the direction of the exchange rate in the very short term in combination with AII stopping techniques. That is shown by an upward-sloping equity lines of our day-trading activity (and the respectable profit rate) over and above a simple Buy-and-Hold strategy and over a 'common sense' approach.

Secondly, both AII closing protocols yield comparable profit results, as they share the same trading decision mechanism to go long or short. But, beyond that, the two AII protocols produce very good SL and TP enhancing profit results, even though their inner functioning is quite different.

References

1. G.Cagliesi, M. Tivegna, Rationality, Behavior and Switching Idiosincracies in the Euro-Dollar Exchange Rate, *Long-run Growth and Short-run Stabilization. Essays in Memory of Albert Ando*, Lawrence R. Klein, E.Elgar, (2006).
2. P.J. Kaufman, *Trading Systems and Methods*, Fifth Edition, John Wiley, (2013).
3. D. Pelusi, Genetic-neuro-fuzzy controllers for second order control systems, *European Modelling Symposium on Computer Modelling and Simulation*, Madrid, Spain, (2011), 12-17.
4. D. Pelusi, M. Tivegna, Optimal trading rules at hourly frequency in the foreign exchange markets, *Mathematical and Statistical Methods for Actuarial Sciences and Finance*, Springer, (2012), 341-348.
5. D. Pelusi, Designing neural networks to improve timing performances of intelligent controllers, *Journal of Discrete Mathematical Sciences and Cryptography*, **16** (2-3), (2013), 187-193.
6. M.Tivegna, Day-Trading the Main Currency Pairs with a News-Based Model of Exchange Rates, *International Conference on Mathematical and Statistical Methods for Actuarial Sciences and Finance*, Venice, Italy (2008).
7. M. Tivegna, G. Chiofi, *News and Exchange rate dynamics*, Ashgate, London (2004).

A procedure for selecting representative subsamples of population from a simple random sample*

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J.E.L. classification: C61, C81, H55, J26, M41.

Abstract

This paper proposes a procedure for selecting large subsamples drawn from a large simple random sample that are more representative of the population under study. We use the Continuous Sample of Working Lives (CSWL), a set of micro data taken from Spanish Social Security records, to illustrate the procedure, finding large subsamples with better representativeness than the original. There are a number of papers that deal with the problem of selecting representative samples, including [1] and [5]. After performing the appropriate statistical tests to find out whether the CSWL sample matches the population on the basis of INSS (2010) statistics report data , [4] concluded that using the CSWL for any kind of analysis could mean that the data selected might not be representative of the population (of pensioners) under study. This result warns us about the effects that using a subsample selected from the CSWL could have on research into some types of benefit.

Our research efforts therefore focused on finding a way to select subsamples representative of the population that were bigger than the subsample we could select from the CSWL using stratified random sample. We consider the distribution by age, gender and type of pension simultaneously. The idea of starting from a big dataset or sample and selecting subsamples from it has been dealt with in different areas of statistics and data analysis, although objectives and procedures vary. One of these methodologies is known as "knowledge discovery in databases (KDD)" and involves the process of discovering useful knowledge from a large dataset, usually known as big data. This widely-used data mining technique is a process that includes data preparation and selection, data cleansing,

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the incorporation of prior knowledge on datasets and the accurate interpretation of solutions from the results observed, as explained by authors such as [2] and [3]. One of the objectives is to obtain subsamples in such a way that, after applying data mining techniques, more representative models can be generated with greater benefits.

The selection criteria for finding a subsample with the necessary characteristics have to take the following requirements into account: They must improve the fit or representativeness with respect to the population under study. The procedure should therefore include a goodness of fit test on the distribution of the number of pensioners by age, gender and type of pension that involves taking into account the associated p-values. In order to achieve the improvement in the selected subsample's representativeness with respect to the population, Pearson's chi-square goodness of fit test is considered. The total number of pensioners needs to be relatively high in order to be bigger than the number that would result from a stratified sample from the original simple random sample.

The sample design criterion chosen substantially improves the representativeness of the pensioner population compared with the CSWL. This is an optimization criterion that maximizes the constant of proportionality q in a proportional allocation stratified sampling design depending on the number of pensions in each age cohort or stratum. It has to satisfy a minimum p-value, which is the same for all the pension and gender types simultaneously, as well as all the restrictions involved in the requirements given earlier. The advantages of using this sample selection design procedure can be seen by comparing the estimate of total pension expenditure provided by the CSWL and that provided by the subsamples obtained. Having large subsamples that are more representative leads to better quality in any subsequent analysis of the sustainability of public pension systems.

References

1. Grafström, A., Schelin, L.: How to select representative samples. (B. of Statistics, Ed.) *Scandinavian Journal of Statistics* **41** (2014) 277-290.
2. Han, J., Kamber, M., Pei, J.: *Data mining: concepts and techniques.* Elsevier (2011).
3. Larose, D.T.: *Discovering knowledge in data: an introduction to data mining.* John Wiley and Sons (2014).
4. Pérez-Salamero González, J. M., Regúlez-Castillo, M., Vidal-Meliá, C.: Análisis de la representatividad de la MCVL: el caso de las prestaciones del sistema público de pensiones. *Hacienda Pública Española/Review of Public Economics* forthcoming.
5. Omair, A.: Sample size estimation and sampling techniques for selecting a representative sample. *Journal of Health Specialties* **2(4)** (2014) 142-147.

Evolutionary approach to combine statistical forecasting models and improve trading system ⋆

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J.E.L. classification: C15, C53, C58, C61, C63.

Abstract

The focus of this contribution is to propose an improvement of *technical analysis* now widely used by many traders. The point is that a huge number of indicators and oscillators has been proposed in the literature but they do not always provide the same signals on a market trend reversal. Furthermore, it is well known that each indicator or oscillator depends on some parameters that are often selected in a subjective way. We are interested to propose a less subjective trading strategy. In this framework two problems arise: on one hand we have to find the weighted combination of the different indicators in order to provide the best possible signal, on the other hand we have to select the best setting of indicators' and oscillators' parameters. In other words we have to tackle an optimization problem that implies the conjoint choice of the parameters characterizing indicators and oscillators and of the associated weights providing a single signal.

A peculiarity of technical analysis is that it neglects the use of the forecasts. So, the technical analysis is focused only on past and current values of time series that can be interpreted as a realization of a unknown data generating process (DGP) that show several recognizable and identifiable patterns. Nevertheless, the presence of pattern detected by the technical analysis implicitly involves the dependencies between the variables of the DGP and suggests the opportunity of using forecasting procedure to anticipate the future behaviour of the quantity considered as input in indicators and oscillators. In other terms, that suggests to use forecasting models. In Mathematics, Statistics and Econometrics literature a large number of papers are devoted to the previsional modelling. The identification of a model which is able to represent the DGP is a starting point to predict future values of the series. Linear models (ARIMA), models with different regimes (Threshold AR, Markov Switching Regimes), evolutionary models (Neural Network, Local Polynomial) are just a few examples. Roughly speaking each model can provide predictions with peculiarities making them complementary to the others for some feature and therefore the performance of the individual forecasts may be improved by using the techniques of the combination of forecasts.

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This contribution has two main aims. The former one is to improve the one-way prediction of the time series of the quantity to use as input in indicators and oscillators by combining statistical forecasting model. The later one is to propose a selection of the parameters characterizing such indicators and oscillators based on a optimization problem. Both the aims are pursued using an evolutionary approach that selects jointly the parameters and the weights.

References

1. Bates, J.M., Granger, C.W.J.: The combination of forecasts. *Operations Research Quartely* **20** (1969) 451-468.
2. Bishop, C.M.: *Neural Networks for Pattern Recognition.* Oxford University Press, Oxford (1995).
3. Box, G., Jenkins, G.: *Time Series Analysis: Forecasting and Control.* Holden-Day, San Francisco (1970).
4. Bopp, A.E.: On combining forecasts: some extensions and results. *Management Science* **31** (1985) 1492-1498.
5. Fan, J., Gijbels, I.: *Local Polynomial Modelling and Its Applications.* Chapman & Hall, New York (1996).
6. Hamilton, J.: Regime-Switching Models. In: Blume, L.E., Durlauf, S.N. (eds.): *New Palgrave Dictionary of Economics* (2nd ed.), Palgrave MacMillan, London (2008) 1-15.
7. Hendry D.F. and Clements M.P.: *Forecasting non-stationary economic time series*, MIT Press, Cambridge (1999). [Zeuthen lecture].
8. Lessmann, S, Sung, M.C., Johnson J.E.V. and Ma, T. A new methodology for generating and combining statistical forecasting models to enhance competitive event prediction. *European Journal of Operational Research* **218** (2012) 163-174.
9. Tong, H., Lim, K.S.: Threshold autoregression, limit cycles and cyclical data (with discussion). *Journal of the Royal Statistical Society*, **Series B 42** (1980) 245-292.

Non-life insurance pricing through Bayesian additive regression trees

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J.E.L. classification: C53, G22.

Abstract

A non-life insurance policy is an agreement between an insurance company and a policyholder, who, against the payment of a fixed premium, receives a compensation for unforeseen damages during a certain time period, according to the policy conditions. When the contract is made, the total amount Y due to the policyholder can be regarded as random: the insurance company acquires economic risks by selling this product. Therefore, modelling the uncertainty of the payout of the insurer is a major issue. In particular, the evaluation of the risk profile of the policyholder becomes a crucial point.

In practice, the *a priori* pure premium P_i is usually estimated using regression methods, which take into account most of the available informations about the i-th policyholder, at the contract stipulation.

Unfortunately, the *a priori* rate-making system is not able to identify all factors that may characterize the new policyholder, since some are unobservable, then the prediction of the true riskness is often biased: this implies the persistent need for an *a posteriori* premium adjustment in function of the observed claims as these data become available (e.g. with the use of Bonus-Malus systems).

Among statistical tools that may improve the ability of claims prediction, Bayesian modelling offer many advantages. In our paper therefore we suppose that $y = (y_1, \dots, y_n)$ is an independent sample of observation of size n from

$$Y_i \sim p(y_i \mid \theta, x_i), \qquad x_i = (x_{i1}, \dots, x_{ip})^T, \quad \text{for } i = 1, \dots, n, \tag{1}$$

where $p(y_i \mid x_i, \theta)$ is the probability density function for the amount due to the i-th policyholder. The random variable Y_i depends on a p-dimensional vector of known covariates x_i and on a vector of unknown p parameters θ. Then, we can define the pure premium as the Bayesian estimate

$$P_i = \mathbb{E}(Y_i^* \mid Y, X, \theta), \tag{2}$$

that is, the expected value of the predictive distribution. From a Bayesian point of view, the quantity P_i is an *a posteriori* estimate, since it is obtained conditionally to a sample of pure premium.

For the risk classification, regression models are tipically in a parametric form and Generalized Linear Models are a common choice. However, it turns out that GLMs rely on somewhat restrictive assumptions. The "wrong" model assumptions may lead to misleading results and therefore a lower premium for an underestimated risk could be asked.

This problem, rather than being purely academic, is called by actuaries "Premium Risk" and appears in the section "Non-Life Underwriting Risk" in the Solvency Capital Requirements (SCR) calculation framework.

To try to avoid these model misspecifications, we present the Bayesian sum-of-trees pricing model (BART), introduced by [2]. This model is based on Bayesian regression trees, where each tree is weak learner thank to a regularitization prior. Moreover, fitting and inference are possible via an iterative Bayesian MCMC algorithm that samples from the posterior loss distribution.

More in details, also to take into account the proportion of zero-claim policies over the entire portfolio, we will propose a zero-inflated non-parametric model of the form:

$$p(y_i \mid \theta) = \gamma_i \delta_0 + (1-\gamma_i) p_0(y_i \mid x_i, \theta), \qquad \text{for } i = 1, \ldots, n, \tag{3}$$

where $0 \leq \gamma_i \leq 1$ is a probability, δ_0 is a point mass in 0 and p_0 is a positive density function. Both γ_i and p_0 will be modelled through independent BART. Compared to other tree-based method, as random forest and boosting, BART are fully probabilistic and therefore the uncertainty of the pure premium can be easily estimated.

References

1. K. Antonio, E. A. Valdez, *Statistical concepts of a priori and a posteriori risk classification in insurance*, Advanced Statistical Analysis, 96 (2012), p. 187–224.
2. H. A. Chipman, E. I. George, and R. E. McCulloch, *BART: Bayesian Additive Regression Trees*, The Annals of Applied Statistics, 4 (2010), p. 266–298.
3. M. Denuit, S. Lang, *Non-life rate-making with Bayesian GAMs*, Insurance: Mathematics and Economics, 35 (2004), p. 627–647.
4. G. W. Fellingham, A. Kottas, B.M. Hartman, *Bayesian nonparametric predictive modeling of group health claims*, Insurance: Mathematics and Economics, 60 (2015), p. 1–10.
5. A. Olivieri, E. Pitacco, Introduction to Insurance Mathematics: Technical and Financial Features of Risk Transfers, Springer Verlag, 2011.
6. E. Ohlsson, B. Johansson, Non-Life Insurance Pricing with Generalized Linear Models, EAA Series, Springer Verlag, 2010.

Conditioning the information in portfolio optimization

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Abstract

This paper proposes a theoretical analysis on the impact of a smaller filtration set on the three main components used in asset pricing, namely the risk physical and neutral measures and the pricing kernel.

The analysis is carried out by means of a portfolio optimization problem for a small and rational investor:

$$\Lambda(x_t) = \sup_{\xi_t \in \mathcal{A}_{\mathcal{I}_t}} E^P[U(X^{\xi_t}(T))] \tag{1}$$

where $\mathcal{A}$ represents the set of admissible portfolios and, its subscript $\mathcal{I}_t$, restricts this set with respect to the information available at time t. As main innovation we analyze the impact of two investors which aim to maximize the same objective function but with two different filtration sets:

$$\mathcal{H}_t \subset \mathcal{F}_t \qquad \forall\, t > 0 \tag{2}$$

where the two information sets are increasing[1] in time and contain all available and potentially usable information:

$$\mathcal{H}_t = \{x_{-\infty}, \dots, x_{t-1}, x_{t-\Delta_t}\} \qquad \text{and} \qquad \mathcal{F}_t = \{x_{-\infty}, \dots, x_{t-1}, x_t\} \tag{3}$$

where Δ_t represents the fraction of missing forward looking information that involves any risky decision to undertake from today, t, with respect to a future time, $t + \tau$ (more on the theoretical effects of projecting the PK onto a coarser filtration set in Sala and Barone-Adesi (2015)[2]). From here on we consider $\mathcal{F}_t$ as the theoretical (or complete) information set and $\mathcal{H}_t$ as the suboptimal information set.

Solving for the maximal expected logarithmic and power utility of the terminal

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[1] Two assumptions underpin this statement: the first is that information is time-varying, the second is that decision makers keep memory of the entire past data.

wealth, we prove the existence of an information premium between what is required by the theory, a complete information set arising from a fully conditional measures, and what is instead used in reality.

$$\Delta_t^{\mathrm{Log}} = \Lambda_{\mathcal{F}_t}^{\mathrm{Log}} - \Lambda_{\mathcal{H}_t}^{\mathrm{Log}} = \frac{1}{2}\int_0^T E^{\widehat{P}}\left[\frac{(\mu(s)-r(s))^2}{\sigma^2(s)} - \frac{(\widehat{\mu}(s)-r(s))^2}{\widehat{\sigma^2}(s)}\right] ds \tag{4}$$

where Δ_t^{Log} represents the time t information premium.
Empirically to have at each point in time a *full* information set as required by the neoclassical theory is usually a mere illusion. As a consequence, the case of an investor with an $\mathcal{H}_t$ information set is much more realistic than the $\mathcal{F}_t$ case. Knowing this point, the more an investor is able to be close to $\mathcal{F}_t$, the better. Therefore, the goal of a good financial modeller should be, for each $t \in T$, to minimize Δ_t as much as possible

$$\min \Delta_t \Rightarrow \max \mathcal{I}_t \tag{5}$$

To minimize Δ_t means to collect and model in the best way possible all the information that is relevant for pricing the assets. A proper estimation of the real world probabilities is then of key importance for many day-by-day operations (i.e.: trading, risk management, asset management). The information premium turns out to be nothing the Kullback-Leiber divergence among the two pricing kernels:

$$\begin{aligned}
D_t^{KL}(M(t)|\hat{M}(t)) &= \mathbb{E}^P\left(\log\frac{\frac{dQ(t)}{dP(t)}}{\frac{d\hat{Q}(t)}{d\hat{P}(t)}}\right) = \mathbb{E}^P\left(\log\frac{M(t)}{\hat{M}(t)}\right) \\
&= \mathbb{E}^P\left(\int_0^t \theta dW_s + \frac{1}{2}\int_0^t \theta_s^2 ds - \int_0^t \hat{\theta} d\hat{W}_s + \frac{1}{2}\int_0^t \hat{\theta}_s^2 ds\right) \\
&= \left(\frac{1}{2}\int_0^t \theta_s^2 - \frac{1}{2}\int_0^t \hat{\theta}_s^2\right) ds \\
&= \theta_t - \hat{\theta}_t = \Delta_t \\
&= \Lambda_{\mathcal{F}_t} - \Lambda_{\mathcal{H}_t}
\end{aligned}$$

Starting from Hansen and Jagganathan (1991)[1] and searching for the best bounds, we study the impact of the premium on the pricing kernel. Finally, exploiting the strong interconnection between the pricing kernel and its densities the extension to the risk-neutral measure follows naturally.

References

1. Hansen, L. and Jagannathan, R.: *Implications of security market data for models of dynamic economies.* Journal of Political Economy, 99-2, (1991)
2. Sala, C., Barone Adesi, G.: *Sentiment lost: the effect of projecting the empirical pricing kernel onto a smaller filtration set.* Working Paper, Available at http://ssrn.com/abstract=2648206, (2015).

Empirical Bayes smoothing splines with correlated noise to study mortality rates

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Abstract

Regression plays a central role in statistics and is a fundamental tool in many applied fields. Even in its signal + noise version this model already admits many variants; here we focus on the estimation of a univariate signal, corrupted with correlated, homoscedastic noise. The regression function, noise level, and correlation structure are all assumed to be unknown parameters of the model. Without imposing any constraints, the estimation of these parameters is infeasible since the model is essentially unidentifiable. Because of this we make some assumptions: the regression function is a smooth signal, and the noise terms are sampled from a stationary, short-range dependent noise process.

A popular way of estimating a regression function is to consider a family of estimators indexed by some (smoothing or bandwidth) parameter and then pick this parameter in some automatic (data-driven) way. In the context of kernel and spline smoothing, researchers quickly realised that well established methods for selecting bandwidth or smoothing parameters like generalised cross-validation (GCV) easily break down in the presence of correlation in the data; cf. [2], [1], [3],[4], [5]; also [6] for some compelling numerical examples. Positively correlated noise, in particular, often leads GVC (and other risk-based methods) to select estimates that severely over-fit the data. More remarkable is that this seems to happen even if the correlation is fairly weak; cf. [6].

In this paper we consider a likelihood based method for estimating the regression function, noise level, and correlation matrix of the noise in a regression model. Our approach consists of endowing the regression function (given the noise level and correlation matrix of the noise) with a so called partially informative Gaussian prior; cf. [7]. Our specific prior depends on the noise level, a parameter and a parameter q, but is constant (flat) over the correlation matrix of the noise. Under this prior, the data can be seen as a realisation of a linear mixed effects model whose mean has as best linear unbiased predictor (BLUP) a smoothing spline with smoothing parameter and whose order is controlled by

q. The noise level can be estimated from the corresponding restricted likelihood; by concentrating out the noise level we obtain a restricted profile likelihood from where we can estimate, q and the correlation matrix of the noise. Maximisers of the restricted profile likelihood are in fact empirical Bayes estimates for these parameters.

We propose a computationally attractive, fully non-parametric method to estimate all model parameters by defining estimates for model parameters , noise level, and correlation matrix, given all others. Starting from an arbitrary estimate of the correlation matrix we cyclically update (using an estimating equation), and the noise level and the correlation matrix (using explicit estimators). One would repeat this procedure until converges but we can show that already after the first iteration we obtain consistent estimates for noise level, and correlation matrix; after a second iteration is already consistent for an oracle smoothing parameter which matches the oracle in the model where the correlation matrix of the noise is actually known. On a second stage we estimate q from an estimating equation following [8]. Computational simulations and an example using mortality rates illustrate the method.

References

1. Altman, N.S.: Kernel smoothing of data qith correlated errors. *Journal of the American Statistical Association* **85** (1990) 749-759.
2. Beran, J., Feng, Y.:Local polynomial estimation with FARIMA-GARCH error process. *Bernoulli* **7** (2001) 733–750.
3. Hart, J.D.: Kernel regression estimation with time series error. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)* **53** (1991) 173-187.
4. Ray, B., Tsay, R.: Bandwidth selection for kernel regression with long-range dependent errors. *Biometrika* **84** (1997) 791–802.
5. Wang, Y.: Smoothing spline models with correlated random errors. *Journal of the American Statistical Association* **93** (1998) 341-348.
6. Opsomer, J.D. , Wang, Y., Yang,Y.: Nonparametric regression with correlated errors. *Statistical science* **16** (2001) 134-153.
7. Speckman, P.L., Sun, D.: Fully Bayesian spline smoothing and intrinsic autoregressive priors. *Biometrika* **90** (2003) 289-302.
8. Serra, P., Krivobokova,T.: Adaptive empirical bayesian smoothing splines (2014). arXiv preprint arXiv:1411.6860.

Optimal portfolio selection for an investor with asymmetric attitude to gains and losses⋆

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Abstract

The description of Cumulative Prospect Theory (CPT) includes three important parts [4]: a value function over outcomes, $v(\cdot)$; a weighting function over *cumulative* probabilities, $w(\cdot)$; CPT-utility as unconditional expectation of the value function v under probability distortion w.

The value function derives utility from gains and losses and is defined as follows [4]:

$$v(x) = \begin{cases} x^{\alpha}, & \text{if } x \geq 0, \\ -\lambda(-x)^{\beta}, & \text{if } x < 0. \end{cases} \tag{1}$$

Let $F_\xi(x)$ be cumulative distribution function (cdf) of a random variable ξ. The probability weighting function $w : [0,1] \to [0,1]$ is defined by

$$w\left(F_\xi(x)\right) = \frac{\left(F_\xi(x)\right)^{\delta}}{\left((F_\xi(x))^{\delta} + (1 - F_\xi(x))^{\delta}\right)^{1/\delta}}, \ \delta \leq 1 \tag{2}$$

Let us consider the problem of choosing an CPT-investor's portfolio in the case of complete market. It is well-known [2] that given the absence of arbitrage opportunities, there is an unique positive stochastic discount factor m, such that the fair price of asset $p = E(mx)$ for any future payoff x, E is the conditional expectation at the initial time $t = 0$. Let W_0 denote the initial wealth (portfolio) of the investor at time $t = 0$. Let $\hat{x}$ denote the payoff of the investor's portfolio at time $t = T$. Then the price of the portfolio at time $t = 0$ is $p(\hat{x}) = E(m\hat{x})$. The problem of finding the optimal portfolio for CPT-investor can be written as

$$E^{\omega}(v(\hat{x} - X)) \to \max_{\hat{x}}, \tag{3}$$

subject to

$$E(m\hat{x}) = W_0, \tag{4}$$

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where X is a reference point, $E^w(\cdot)$ denotes the transformed expected value of $(\cdot)$ under the probability transformation w, the maximum is taken over all state of nature at time T.

We will assume that $\delta = 1$, i.e. transformation w is the identity operator. Then $E^w(\cdot) = E(\cdot)$ and the first order condition at the state $\hat{x}$ is

$$v'(\hat{x} - X) = \theta m, \tag{5}$$

where θ is the Lagrange multiplier. The solution of the problem (3)-(4) is

$$\hat{x} = {v'}^{-1}(\theta m) + X.$$

We will assume that the price S of risky asset follows the standard log-normal diffusion process given by the stochastic differential equation known as Geometric Brownian Motion: $\frac{dS}{S} = \mu dt + \sigma dz$, where μ is a drift, σ is a standard deviation, $dz = \epsilon\sqrt{dt}$, the random variable ϵ is a standard normal, $\epsilon \sim N(0,1)$. We will assume that there is also a money market security that pays the real interest rate rdt (risk-free asset): $\frac{dB}{B} = rdt$. Then [2] the discount factor Λ follows the process $\frac{d\Lambda}{\Lambda} = -rdt - \frac{\mu - r}{\sigma}dz$. We can prove the following proposition.

Theorem 1. *If* $\delta = 1$ *then the solution* $\hat{x}$ *of the problem* (3)-(4) *is unique and defined by*

$$\hat{x} = \begin{cases} X - (Xe^{-rT} - W_0)e^{(1-\nu)(r + \frac{1}{2}\nu\sigma^2)T} R_T^{\nu}, \ \hat{x} < X, \\ (W_0 - Xe^{-rT})e^{(1-\gamma)(r + \frac{1}{2}\gamma\sigma^2)T} R_T^{\gamma} + X, \ \hat{x} \geq X, \end{cases}$$

where $R_T = S_T/S_0$, $\nu = \frac{1}{1-\beta}\frac{\mu - r}{\sigma^2}$ *and* $\gamma = \frac{1}{1-\alpha}\frac{\mu - r}{\sigma^2}$.

The theorem says that the optimal portfolio consists of two part: the bond that guarantees the payoff X at time $t = T$, and the wealth $(W_0 - Xe^{-rT})$ invested under power utility maximization.

Moreover, we can conclude that if $\delta = 1$ and $X = W_0 e^{rT}$ then the optimal portfolio is $\hat{x} = W_0 e^{rT}$.

References

1. Barberis, N. C. Thirty years of prospect theory in economics: A review and assessment. *Journal of Economic Perspectives* **27** 1 (2013) 173-196.
2. Cochrane, J. H. *Asset Pricing.* Princeton University Press, Princeton and Oxford (2005).
3. Kahneman, D., Tversky, A. Prospect theory: An analysis of decision under risk, *Econometrica* **62** (1979) 1291-1326.
4. Tversky, A., Kahneman, D. Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty* **5** (1992) 297-323.

The impact of liquidity regulation announcements on the CDS market of large European banks

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Abstract

This study examines how the Credit Default Swap (CDS) market reacted to announcements by the Basel Committee on Banking Supervision (BCBS) concerning liquidity regulation, a key milestone in the new Basel III framework.
Following the financial crisis erupted in summer 2007, European banks, despite meeting the regulatory capital requirements, experienced serious funding difficulties due to their improper liquidity risk management. In response to the vulnerabilities arose, the BCBS undertook a negotiation process of international standards to address the previously neglected role of liquidity risk. During this negotiation period (2008-2015) several amendments were issued by the BCBS prior to the final version of the new liquidity reform package.
This paper is the *first* empirical analysis testing how the gradual release of official documents on liquidity regulation has affected creditors' perception of bank default risk. To this purpose, using European banks' CDS spreads as proxy for the effect on creditors, we run an event study analysis [5] to estimate cumulative abnormal spread changes (CARs) around announcement days. Furthermore, we measure the heterogenous response of creditors to regulatory events and try to investigate the main determinants of this variety. This aim requires a second stage analysis, in which CARs are regressed on bank-specific variables and controls [6].
From the event study analysis, we find evidence of a positive CDS market reaction to regulatory announcements, as expressed by a decline in the CDS spread for all events under examination. This finding suggests that bondholders (in a short run perspective) have perceived the new liquidity standards as a being conducted to create net benefits on banks, thus reducing their expectation of a bank failure. Moreover, it shows that liquidity regulation was, to some extent, effective in restoring investor confidence in the banking system, in line with the objectives of Basel III. Importantly, this result is robust to different parametric and nonparametric test statistics [8, 1, 3].
From the regression analysis, consistently with the work by [2], we document that

bank liquidity, funding structure and asset quality cause heterogeneous CDS reactions. In contrast, we show that bank profitability does not explain variations in CARs.
Surprisingly, while there are several papers dealing with regulatory events and their impact on the market (e.g., [4, 7]) the studies on bank liquidity regulation are scant [2]. Furthermore, among these few pieces of research, to the best of our knowledge, there is no empirical analysis focusing on creditors and examining the complete series of announcements leading to the new liquidity framework. Our paper has several, important implications. First, it provides greater insight and new knowledge on the market effect of liquidity regulation, an area that is relatively unexplored in the literature on banking regulation. Second, this research sheds light on the increasingly important relationship between the dimension of bank liquidity and that of solvency. Third, this work supports regulators in assessing the effectiveness of Basel III. Finally, the estimated reduction in creditors' expectation of bank default risk reflects a decline in the cost of debt, which may, to some extent, offset the downward pressures of the new liquidity requirements on bank lending spread, with potential positive benefits on profitability.
In this framework, the figure of bondholders is particularly interesting for two main reasons. First, they are excluded from Deposit Insurance Schemes: the lack of protection schemes, together with the hard period that the banking system was experiencing, should have raised creditors' concern on bank soundness and insolvency risk. As a second reason, following the publication on 12th June 2014 in the Official Journal of the European Union (EU) of the Bank Recovery and Resolution Directive (BRRD), the protection of bondholders has significantly reduced. Consequently, creditors' exposure to losses substantially rose, making this figure more sensitive to credit risk and particularly interesting for the purpose of this study.

References

1. Boehmer, E., Musumeci, J., Poulsen, A.: Event-study methodology under conditions of event-induced variance *Journal of Financial Economics* **30** (1991) 253-272.
2. Bruno, B., Onali, E., Schaeck, K.: Market reaction to bank liquidity regulation. European Financial Management Association, Working Paper (2015) 1-52.
3. Cowan, A.R.: Nonparametric event study tests *Review of Quantitative Finance and Accounting* **2** (1992) 343-358.
4. James, C.: An analysis of intra-industry differences in the effect of regulation: the case of deposit rate ceilings *Journal of Monetary Economics* **12** (1983) 417-432.
5. MacKinlay, A.C.: Event studies in economics and finance *Journal of Economic Literature* **35** (1997) 13-39.
6. Ricci, O.: The impact of monetary policy announcements on the stock price of large European banks during the financial crisis *Journal of Banking & Finance* **52** (2015) 245-255.
7. Wagster, J.D.: Impact of the 1988 Basle Accord on international banks *Journal of Finance* **51** (1996) 1321-1346.
8. Wilcoxon, F.: Individual comparisons by ranking methods *Biometrics Bulletin* **1** (1945) 80-83.

Bonds historical simulation Value at Risk*

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Abstract

Due to the pull to par evolution of bond prices, bonds historical returns tend to zero as time to maturity approaches. As a consequence, bonds historical returns can not be used to compute Value at Risk (VarR) by historical simulation. They would systematically overestimate VaR.

In this paper we propose an adjustment of bonds historical returns, that allows computing VaR by historical simulation. The aim of our proposal is to compute VaR by historical simulation of portfolios with bonds, keeping the same level of simplicity the historical simulation method allows, for instance, for stocks.

The adjusted historical returns are computed from the bond valuation at present time (the time VaR is computed) and at present time plus the VaR time horizon, using historical prices on dates that differ by the VaR time horizon and the corresponding implied yields to maturity.

The overall result is that of computing adjusted historical returns based on bond values that exhibit the same times to maturity as the prices used in the present return, while preserving the historical market movements. Since the times to maturity are the same, the pull to par evolution of the adjusted historical returns will match the pull to par evolution of the present return, allowing the VaR computation by historical simulation.

Denoting by t the current time, by $h < t$ the historical time, by $T > t$ a zero coupon bond maturity time, by $r(t)$ the short rate and considering a backtesting point of view, we show that the proposed method applies whenever the probability distribution of the following short rate integrals equals.

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$$\frac{\int_h^t r(u)du}{t-h} \sim \frac{\int_h^T r(u)du}{T-h} \tag{1}$$

We present a constant mean Gaussian short rate model which we prove verifies Equation 1.

We evaluate the proposed method on a long term subset of Bloomberg Eurozone Sovereign Bond Index (BEUR), using the standard coverage tests [1]. The results show that the proposed bonds adjusted returns do allow the computation of VaR by historical simulation for portfolios with bonds.

We identify the following strengths of the proposed method. The portfolio specific VaR is computed while using the market as the only source of information. Neither subjective risk factors mapping [2], risk factors correlations, standard maturities interpolation, nor ratings, are needed.

Regarding the weaknesses, the proposed method inherits all the known weaknesses of the historical simulation method, namely, the need of synchronized historical data for all securities in the portfolio [3].

References

1. Christoffersen, P. F.: Evaluating interval forecasts. *International Economic Review*, **39** (1998) 841862.
2. Alexander, C.: *Market Risk Analysis, Value at Risk Models.* John Wiley & Sons, 2009.
3. McNeil, A.J. and Frey, R. and Embrechts, P.: *Quantitative Risk Management: Concepts, Techniques, and Tools.* Princeton University Press, 2005.

Fitting models to cumulative returns with a Genetic Algorithm*

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Abstract

Many real problems need to model a data set, being important to consider several statistical distribution models, and different estimation methods have been used to fit such models and examine the stochastic behaviour of these data. Classical methods have been successfully used for fitting of probability distribution models to data.

Nevertheless, the well-known disadvantages showed by them have carried out to seek alternative methods as such the genetic algorithm (GA) [4], which has recently received considerable attention as it can be used for complex distribution models or when big data sets must be fitted. Originally, the GA was developed by [2] as a model of genetic evolution, have swiftly evolved to be used in lots of different areas due to their robustness and their ability to search in a noisy problem space, providing optimization tools that search for the best solution by mimicking the evolution of a population.

Within this framework, fitting distribution models to the daily cumulative returns on a stock market index has been an important issue in financial data analysis. In [3], the normal inverted gamma mixture (NIG) and the double Weibull (DW) distribution models were proposed to fit daily cumulative returns, and these models are also characterized by belonging to the class of symmetric distributions. For an illustrative example, these proposed distribution models were better fitting than various competitive models including the log-normal, the Burr and the symmetric α-stable distributions.

More recently, [1] studied the generalized trapezoidal (GT) model which belongs to the nonparametric class of log-concave probability density functions under determined parametric restrictions, and observed that this distribution can be useful in analyzing some data sets. Especially, a financial market data example was used to illustrate that the GT model was better fitting than the symmetric distributions previously considered for this data set by [3].

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The main goal of this work is to apply the GA method for fitting some distribution models, and then compare these fitted models with the ones obtained by using the procedure of the least squares used in [1] to estimate the coefficients of proposed models for the daily cumulative returns. It is hypothesized that the approach of using GA to estimate the parameters of daily cumulative returns distributions would better fit the daily cumulative returns model than the use of the least squares.

The data used for the illustrative application in [1] and [3], consisting of the Swiss Market Index (SMI) daily cumulative returns between September 29, 1998 and September 24, 1999, is reused in the present study. The data are fitted to GT, NIG and DW distribution models using the GA package [5] and the least squares procedure. Furthermore, the fitting of the NIG, WD and GT models to an updated data set of the SMI daily cumulative returns is carried out by using GA method.

References

1. Franco, M., van Dorp, J.R.., Vivo, J.M.: The generalized trapezoidal model in financial data analysis. In: Perna, C., Sibillo, M. (eds.): *Mathematical and Statistical Methods for Actuarial Sciences and Finance*, Vol. I., Springer (2012) 219-227.
2. Holland, J.H.: *Adaption in Natural and Artificial Systems.* Ann Arbor (MI), University of Michigan Press (1975).
3. Hürlimann, W.: Financial data analysis with two symmetric distributions. *Astin Bulletin* **31** (2001) 187-211.
4. Messa, K., Lybanon, M.: *Curve fitting using genetic algorithms.* Technical report 18, Naval Oceanographic and Atmospheric Research Laboratory (NOARL) (1991).
5. Scrucca, L.: GA: A Package for Genetic Algorithms in R. *Journal of Statistical Software* **53** (2013) 1-37.