

# LIST OF ABSTRACTS 2019

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**2019/01**

## Minimum Rényi entropy portfolios

Nathan Lassance and Frédéric Vrins

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Accounting for the non-normality of asset returns remains challenging in robust portfolio optimization. In this article, we tackle this problem by assessing the risk of the portfolio via the "amount of randomness" conveyed by its returns. We achieve this using an objective function that relies on the exponential of *Rényi entropy*, an information-theoretic criterion that precisely quantifies the uncertainty embedded in a distribution, accounting for higher-order moments. Compared to Shannon entropy, Rényi entropy features a parameter that controls the way uncertainty is measured. A Gram-Charlier expansion shows that the parameter controls for the relative contributions of the central (variance) and tail (kurtosis) parts of the distribution. We further rely on a non-parametric estimator of the exponential Rényi entropy, which extends a robust sample-spacings estimator initially designed for Shannon entropy. A portfolio selection application illustrates that minimizing Rényi entropy yields portfolios that outperform robust minimum variance portfolios in terms of risk-return-turnover trade-off.

**Keywords:** portfolio selection, Shannon entropy, Rényi entropy, risk measure, information theory

**2019/02**

## Insurance with a deductible. A way out of the long term care insurance puzzle

Justina Klimaviciute and Pierre Pestieau

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Long-term care (LTC) is one of the largest uninsured risks facing the elderly. In this paper, we first survey the standard causes of what has been dubbed the LTC insurance puzzle and then suggest that a possible way out of this puzzle is to make the reimbursement formula less threatening for those who fear a too long period of dependence. We adopt a reimbursement formula resting on Arrow's theorem of the deductible, i.e. that it is optimal to focus insurance coverage on the states with largest expenditures. It implies full self-insurance for the first years of dependency followed by full insurance thereafter. We show that this result remains at work with ex post moral hazard.

**Keywords:** long-term care insurance, deductible, Arrow's theorem, reimbursement rule

**JEL codes:** G22, I13, J14

**2019/03**

## The performance of public enterprises

Sergio Perelman and Pierre Pestieau

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The purpose of this paper is to argue in favour of public enterprises that would be accountable for their performance, that is the way they fulfil the missions assigned to them by the public authority. This requires a rigorous and regular performance assessment. If adopted earlier such an approach would have avoided unneeded and costly privatizations as well as being trapped by inefficient public-private partnership arrangements. Recent evidence on enterprise performance seems to point out that institutions matters more than ownership.

**Keywords:** privatization, performance, public enterprises, public-private partnership

**2019/04**

## Investment in children, social security, and intragenerational risk sharing

Simon Fan, Yu Pang and Pierre Pestieau

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We analyze the role of pay-as-you-go social security in intragenerational risk sharing in an overlapping-generations model with individual heterogeneity. Parents invest in their children's education in exchange for old-age support financed by a fraction of their children's future earnings. Due to random factors such as luck in the job market, children may have different earning capacities even if they receive the same education. Without social security, a parent receives a transfer payment from her own child, so the received amount is uncertain as it depends on the child's earnings. The social security scheme of pooling transfer contributions from all children and then returning them equally to each parent insures parents against the risks of educational investments. Our model shows that social security stimulates educational spending, increases labor earnings, and improves social welfare (as measured by *ex ante* individual utility). However, it worsens *ex post* intragenerational income equality (as measured by the Gini coefficient for lifetime income).

**Keywords:** old-age insurance, social security, public education, income inequality

**JEL codes:** D81, H20, H55, I24

**2019/05**

### Missing poor in the U.S.

Mathieu Lefebvre, Pierre Pestieau and Gregory Ponthiere

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Given that poor individuals face worse survival conditions than non-poor individuals, one can expect that a steeper income/mortality gradient leads, through stronger income-based selection, to a lower poverty rate at the old age (i.e. the «missing poor» hypothesis). This paper uses U.S. state-level data on poverty at age 65+ and life expectancy by income levels to provide an empirical test of the missing poor hypothesis. Using air pollution as an instrument for mortality differentials, we show that instrumented changes in mortality differentials have a negative and statistically significant effect on old-age poverty: a 1% increase in the mortality differential implies a 9% decrease in the 65+ headcount poverty rate. Using those regression results, we compute hypothetical old-age poverty rates while neutralizing the impact of the income/mortality gradient, and show that correcting for heterogeneity in income-based selection effects modifies the comparison of old-age poverty prevalence across states.

**Keywords:** poverty, measurement, income/mortality gradient, selection biases, comparability

**JEL codes:** I32

**2019/06**

### Ratings, reviews, recommendations and the consumption of cultural goods

Paul Belleflamme and Martin Peitz

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In this short paper, we elaborate on the importance of ratings, reviews and recommendations (short, 3R systems) for the consumption of cultural goods. Our aim is to provide a non-technical perspective on the issue informed by the existing literature on the topic.

**Keywords:** cultural goods, rating system, recommender system, consumer feedback, long tail

**2019/07**

### Endogenous vertical segmentation in a Cournot oligopoly

Paul Belleflamme and Valeria Forlin

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An arbitrary number of (ex ante symmetric) firms first choose whether to produce a high-quality or a low-quality product and then, the quantity of product to put on the market. We establish the following results: (i) there exists competition within and across quality segments; (ii) firms may be better off producing the low quality if competition within this segment is sufficiently low; (iii) a firm's switch across qualities may benefit all the other firms; (iv) there exists a unique partition of the firms between the two quality segments; (v) if high quality has a larger cost-quality ratio, then the equilibrium exhibits vertical differentiation; (vi) there may be too much differentiation from the consumers' point of view.

**Keywords:** quality, differentiation, oligopolistic competition

**JEL codes:** D43, L13, L25

**2019/08**

### Fair long-term care insurance

Marie-Louise Leroux, Pierre Pestieau and Gregory Ponthiere

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The study of the optimal long-term care (LTC) social insurance is generally carried out under the utilitarian social criterion, which penalizes individuals who have a lower capacity to convert resources into well-being, such as dependent elderly individuals or prematurely dead individuals. This paper revisits the design of optimal LTC Insurance while adopting the *ex post* egalitarian social criterion, which gives priority to the worst-off in realized terms (i.e. once the state of nature has been revealed). Using a lifecycle model with risk about the duration of life and risk about old-age dependence, it is shown that the optimal LTC social insurance is quite sensitive to the postulated social criterion. The optimal second-best social insurance under the *ex post* egalitarian criterion involves, in comparison to utilitarianism, higher LTC benefits, lower pension benefits, a higher tax rate on savings, as well as a lower tax rate on labor earnings.

**Keywords:** long-term care, social insurance, fairness, mortality, compensation, egalitarianism

**JEL codes:** J14, L131 H55

**2019/09**

### Multi-hub express shipment service network design with complex routes

José Miguel Quesada Pérez, Jean-Sébastien Tancrez and Jean-Charles Lange

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The *Express Shipment Service Network Design (ESSND)* problem consists in defining a network of flights that enables the overnight flow of express packages from their origins to their destinations at minimum cost. This problem is normally solved considering only one-leg, multi-leg and ferry routes. Assessing the value of more complex route types is an open question of academic and practical importance. In this article, we present a mixed integer programming model that includes five types of complex routes: two-hub, transload, direct, inter-hub and early routes. We assess their economic impact by performing many experiments built from an instance provided by FedEx Express Europe. Inter-hub and early routes have the best performance, with significant average savings (from 0.5% to 3.5%).

**Keywords:** service network design, express integrator, multiple hubs, flexible hub assignment, mixed integer programming, complex routes

**2019/10**

### Alternative representation of semivalues, the inverse problem and coalitional rationality

Irinel Dragan and Pierre Dehez

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The concept of semivalue of a transferable utility game has been introduced by Dubey, Neyman and Weber as weighted sum of marginal contributions. Later, Puente has introduced a particular class of semivalues, called binomial semivalues, where weights are obtained through a recursive procedure. In the present paper, we extend Puente's procedure to obtain an equivalent representation of semivalues that turns out to be useful to solve the inverse problem and the question of coalitional rationality.

**Keywords:** transferable utility games, semivalues, inverse problem, power game  
**JEL codes:** C71

**2019/11**

### Price disclosure by two-sided platforms

Paul Belleflamme and Martin Peitz

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We consider two-sided platforms with the feature that some users on one or both sides of the market lack information about the price charged to participants on the other side of the market. With positive cross-group external effects, such lack of price information makes demand less elastic. A monopoly platform does not benefit from opaqueness and optimality reveals price information. By contrast, in a two-sided singlehoming duopoly, platforms benefit from opaqueness and, thus, do not have an incentive to disclose price information. In competitive bottleneck markets, results are more nuanced: if one side is fully informed (for exogenous reasons), platforms may decide to inform users on the other side either fully, partially or not at all, depending on the strength of cross-group external effects and the degree of horizontal differentiation.

**Keywords:** price transparency, two-sided markets, competitive bottleneck, platform competition, price information, strategic disclosure

**2019/12**

### A bargaining set for roommate problems

Ata Atay, Ana Mauleon and Vincent Vannetelbosch

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Since stable matchings may not exist, we adopt a weaker notion of stability for solving the roommate problem: the bargaining set. Klijn and Massó (2003) show that the bargaining set coincides with the set of weakly stable and weakly efficient matchings in the marriage problem. First, we show that a weakly stable matching always exists in the roommate problem. However, weak stability is not sufficient for a matching to be in the bargaining set. Second, we prove that the bargaining set is always non-empty. Finally, as Klijn and Massó (2003) get for the marriage problem, we show that the bargaining set coincides with the set of weakly stable and weakly efficient matchings in the roommate problem.

**Keywords:** roommate problem, matching, (weak) stability, bargaining set  
**JEL codes:** C71, C78

**2019/13**

### Exponential-type GARCH models with linear-in-variance risk premium

Christian M. Hafner and Dimitra Kyriakopoulou

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One of the implications of the intertemporal capital asset pricing model (CAPM) is that the risk premium of the market portfolio is a linear function of its variance. Yet, estimation theory of classical GARCH-in-mean models with linear-in-variance risk premium requires strong assumptions and is complete. We show that exponential-type GARCH models such as EGARCH or Log-GARCH are more natural in dealing with linear-in-variance risk premia. For the popular and more difficult case of EGARCH-In-mean, we derive conditions for the existence of a unique stationary and ergodic solution and invertibility following a stochastic recurrence equation

approach. We then show consistency and asymptotic normality of the quasi maximum likelihood estimator under weak moment assumptions. An empirical application estimates the dynamic risk premia of a variety of stock indices using both EGARCH-M and Log-GARCH-M models.

**Keywords:** GARCH-in-Mean, EGARCH, Log-GARCH, CAPM, risk premium, maximum likelihood, stochastic recurrence equation  
**JEL codes:** C13, C22, C51, G12

**2019/14**

### Crowdfunding dynamics

Paul Belleflamme, Thomas Lambert and Armin Schwienbacher

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Various forms of social learning and network effects are at work on crowdfunding platforms, giving rise to informational and payoff externalities. We use novel entrepreneur-backer data to study how these externalities shape funding dynamics, within and across projects. We find that backers decide to back a particular project based on past contributions not only to that project - as documented by prior work - but also to other contemporaneous projects - a novel result. Our difference-in-differences estimates indicate that such 'cross-project funding dynamics' account for 4-5% in the increase of contributions that projects generate on a daily basis. We show that recurrent backers are the main transmission channel of cross-project funding dynamics: by initiating social learning about project existence and quality, recurrent backers encourage future funding by other backers. Our results demonstrate that even though contemporaneous projects compete for funding, they jointly benefit from their common presence on the platform. We finally show that these crowdfunding dynamics stir platform growth, with important consequences for competition among platforms.

**Keywords:** crowdfunding, digital platforms, FinTech, network effects, social learning  
**JEL codes:** D43, G23, L14, L26, L86

**2019/15**

### Making a difference: European mutual funds distinctiveness and peers' performance

Sophie Béreau, Jean-Yves Gnabo and Henri Vanhomwegen

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Skilled managers of equity mutual funds can develop innovative strategies to outsmart their style peers. We unveil various causes of distinct investment strategies and test whether they materialize into outperformance of peer competitors. We frame our paper on European funds and propose a novel procedure to measure and test the impact of strategy distinctiveness while dealing with endogenous style classification and sample noise in peers' comparisons of performance. We find a strong, robust and positive impact of strategy distinctiveness on financial performance. Yet, the marginal effect decreases with the level of distinctiveness.

**Keywords:** European equity mutual funds, distinctiveness, commonality, peer performance, adaptive clustering  
**JEL codes:** G11, G12, G23

**2019/16**

### Investing in superheroes? Comic art as a new alternative investment

Fabian Bocart, Christian Hafner, Yulia Kasperskaya and Marti Sagarra

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Drawing on an exclusive dataset of more than 106,000 items of comic art sold at auciton, we build quarterly and semi-annual indices for American and European comic art. We find that this new type of alternative investment outperformed US and European equities and bonds. Between 2002 and 2017, annualized returns of US comic artworks clearly outperformed most asset classes with a solid 11% annualized return, while European comic art achieved 25% yearly returns on average in the period after 2009. We show that comic art delivers significant diversification benefits to an investment portfolio thanks to low correlations with other assets and to the geographical diversification between European and American markets. These outcomes contrast with fine art in general, which delivered few diversification benefits when compared to equities and bonds between 2002 and 2017, and whose geographical markets are closely tied to each other.

**Keywords:** comic art, alternative investments, auctions, hedonic regressions, price index, portfolio  
**JEL codes:** C2, G1, Z1, Z11

**2019/17**

### Do sugar taxes affect the right consumers?

Valerio Serse

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Sugar taxes are often considered as a possible tool to tackle excessive sugar consumption. This paper estimates a dynamic multinomial Logit model of cola demand on a novel supermarket scanner dataset in order to study preference heterogeneity and state dependence in product choice. The model estimates allow evaluating the effectiveness of taxation in reducing demand for sugary colas across different consumer types. The results show that a sugar tax would be less effective among the targeted population of heavy sugar consumers. This policy, however, would be more effective among low-income households. Tax policy simulations

show that a specific tax on sugar should be preferred to an ad-valorem tax on sugary colas on both corrective and equity grounds. This is because ad-valorem taxes can lead low-income households and heavy sugar consumers to substitute from expensive to cheaper sugary brands. Lastly, because households exhibit state dependence in cola choice, sugar taxes would be more effective in reducing sugar consumption in the long-run.

**Keywords:** heterogeneity in preferences, state dependence, sugar taxes, discrete choice models

**JEL codes:** D12, H31, I18, Q18

**2019/18**

## A model of the optimal allocation of government expenditures

Simon Fan, Yu Pang and Pierre Pestieau

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Government expenditures can be used for various socio-economic objectives, including public education, consumption of public goods and services, and social protection. This paper analyzes the optimal allocation of public expenditures among these competing functions. We establish an overlapping generations model with heterogeneous individuals in which the government optimally chooses income tax, transfer payment, educational spending, and public consumption. Our model characterizes the transitional dynamics and the steady state of each function with and without a pay-as-you-go international contract. We also conduct a simulation illustrating that the presence of an intergenerational contract may raise public consumption and social welfare in the steady state.

**Keywords:** government spending, public education, public consumption, individual heterogeneity

**JEL codes:** H20, H31, H50

**2019/19**

## The competitive impacts of exclusivity and price transparency in markets with digital platforms

Paul Belleflamme and Martin Peitz

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Two-sided digital platforms not only decide about the price structure, but often have non-price instruments at their disposal. Our objective in this article is to review recent work that aims at better understanding the possible pro- or anti-competitive effects of two specific non-price strategies: exclusivity as the contractual obligation to singlehome and price transparency as the disclosure of information about otherwise unobserved prices paid by users on the other side. Regarding the incentives that platforms may have to restrict users from visiting more than one platform at a time, one finding is that when platforms find it profitable to impose exclusivity on one side, users on the other side always suffer. Regarding price transparency in situations in which users on one side may not observe the prices that platforms set on the other side, we find that a monopoly platform is willing to remedy this problem by being transparent about all prices, whereas competing platform would in general prefer more opaqueness. From our findings we derive lessons for competition authorities.

**Keywords:** platform competition, competitive bottleneck, exclusivity contracts, price disclosure, price transparency

**2019/20**

## Benders' algorithm with (mixed)-integer subproblems

Dieter Weninger and Laurence A. Wolsey

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We consider problems of the form  $\min\{cx + hy : Ax + By \geq b, x \in Z^{\ell}, y \in Y \subseteq R^{\ell+p}\}$  that are often treated using Benders' algorithm, but in which some of the  $y$ -variables are required to be integer. We present two algorithms that hopefully add to and clarify some of the algorithms proposed since the year 2000. Both are branch-and-cut algorithms solving linear programs by maintaining a strict separation between a Master problem in  $(x, \eta)$ -variables and a subproblem in the  $y$ -variables. The first involves nothing but the solution of linear programs, but involves branching in  $(x, y)$ -space. It is demonstrated on a small capacitated facility location problem with single-sourcing. The second restricted to problems with  $x \in \{0,1\}^{\ell}$  only requires branching in the  $x$ -space, but uses cutting planes in the subproblem based on the integrality of the  $y$ -variables that are converted/lifted into valid inequalities for the original problem in  $(x, y)$ -variables. For the latter algorithm we show how the lifting can be carried out trivially for several classes of cutting planes. A 0-1 knapsack problem is provided as an example. To terminate we consider how the information generated in the course of the algorithms can be used to carry out certain post-optimality analysis.

**Keywords:** Benders' algorithm, mixed -integer subproblems, branch-and-cut, value function

**AMS 2010 Mathematics Subject Classification:** 90C10, 90C11, 49M27, 65K05

**2019/21**

## Local convergence of tensor methods

Nikita Doikov and Yurii Nesterov

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In this paper, we study local convergence of high-order Tensor Methods for solving convex optimization problems with composite objective. We justify local superlinear convergence under the assumption of uniform convexity of the smooth component, having Lipschitz-continuous higher-order derivative. The convergence both in function value and in the norm of minimal subgradient is established. Global complexity bounds for the Composite Tensor Method in convex and uniformly convex cases are also discussed. Lastly, we show how local convergence of the methods can be globalized using the inexact proximal iterations.

**Keywords:** convex optimization, higher-order methods, tensor methods, local convergence, uniform convexity, proximal methods

**2019/22**

## Gradient methods with memory

Yurii Nesterov and Mihai I. Florea

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In this paper, we consider gradient methods for minimizing smooth convex functions, which employ the information obtained at the previous iterations in order to accelerate the convergence towards the optimal solution. This information is used in the form of piecewise linear model of the objective function, which provides us with much better prediction abilities as compared with the standard linear model. To the best of our knowledge, this approach was never really applied in Convex Minimization to differentiable functions in view of the high complexity of the corresponding auxiliary problems. However, we show that all necessary computations can be done very efficiently. Consequently, we get new optimization methods, which are better than the usual Gradient Methods both in the number of calls of oracle and in the computational time. Our theoretical conclusions are confirmed by preliminary computational experiments.

**Keywords:** convex optimization, gradient methods, relative smoothness, rate of convergence, piece-wise linear model

**2019/23**

## Inexact basic tensor methods

Yurii Nesterov

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In this paper we analyze the Basic Tensor Methods, which use approximate solutions of the auxiliary problems. The quality of this solution is described by the residual in the function value, which must be proportional to  $\epsilon^{1/(p+1)}$ , where  $p \geq 1$  is the order of the method and  $\epsilon$  is the desired accuracy in the main optimization problem. We analyze in details the auxiliary schemes for the third- and the second-order tensor methods. The auxiliary problems for the third-order scheme can be solved very efficiently by a linearly convergent gradient-type method with a preconditioner. The most expensive operation in this process is a preliminary factorization of the Hessian of the objective function. For solving the auxiliary problem for the second order scheme, we suggest two variants of the Fast Gradient Methods with restart, which converge as  $O(1/k^6)$ , where  $k$  is the iteration counter. Finally, we present the results of the preliminary computational experiments.

**Keywords:** high-order methods, tensor methods, complexity bounds, convex optimization

**2019/24**

## Childlessness, childfreeness and compensation

Marie-Louise Leroux, Pierre Pestieau and Gregory Ponthiere

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We study the design of a fair family policy in an economy where parent-hood is regarded either as desirable or as undesirable, and where there is imperfect fertility control, leading to involuntary childlessness/parenthood. Using an equivalent consumption approach in the consumption-fertility space, we first show that the identification of the worst-off individuals is not robust to how the social evaluator sees the reference fertility level. Adopting the ex post egalitarian social criterion, which gives priority to the worst off in realized terms, we then examine the compensation for involuntary childlessness/parenthood. Unlike real-world family policies, a fair family policy does not always involve positive family allowances to (voluntary) parents, and may also, under some reference fertility levels, involve positive childlessness allowances. Our results are robust to assuming asymmetric information and to introducing Assisted Reproductive Technologies.

**Keywords:** fertility, childlessness, family policy, compensation, fairness.

**JEL codes:** J13, I38

**2019/25**

## DCC-HEAVY: A multivariate GARCH model based on realized variances and correlations

Luc Bauwens and Yongdeng Xu

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This paper introduces the DCC-HEAVY and DECO-HEAVY models, which are dynamic models for conditional variances and correlations for daily returns based on measures of realized variances and correlations built from intraday data. Formulas for multi-step forecasts of conditional variances and correlations are provided. Asymmetric versions of the models are developed. An empirical study shows that in terms of forecasts the new HEAVY models outperform the BEKK-HEAVY model based on realized covariances, and the BEKK, DCC and DECO multivariate GARCH models based exclusively on daily data.

**Keywords:** dynamic conditional correlations, forecasting, multivariate HEAVY, multivariate GARCH, realized correlations

**JEL codes:** C32, C58, G17

2019/26

## Exact gradient methods with memory

Mihai I. Florea

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The Inexact Gradient Method with Memory (IGMM) is able to considerably outperform the Gradient Method by employing a piecewise linear lower model on the smooth part of the objective. However, this model cannot be solved exactly and IGMM relies on an inaccuracy term  $\delta$ . The need for a bound on inexactness narrows the range of problems to which IGMM can be applied. In addition,  $\delta$  carries over to the worst-case convergence rate. In this work, we show how a simple modification of IGMM eliminates the reliance on  $\delta$  for convergence. The resulting Exact Gradient Method with Memory (EGMM) is as broadly applicable as the Bregman Distance Gradient Method (NoLips) and has a worst-case rate of  $\mathcal{O}(1/k)$ , recently shown to be optimal for its class. Moreover, the elimination of  $\delta$  allows us to accelerate EGMM without error accumulation, yielding an Accelerated Gradient Method with Memory (AGMM) possessing a worst-case rate of  $\mathcal{O}(1/k^2)$  on the largest subclass of problems for which acceleration is known to be attainable. Preliminary computational experiments show that the flexibility of our model enables EGMM to surpass IGMM in practical performance. The convergence speed of AGMM also consistently exceeds that of FGM, even with small bundles.

**Keywords:** gradient method, bundle, piece-wise linear model, acceleration, Bregman distance, relative smoothness, composite problem

2019/27

## Contracting proximal methods for smooth convex optimization

Nikita Doikov and Yurii Nesterov

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In this paper, we propose new accelerated methods for smooth Convex Optimization, called Contracting Proximal Methods. At every step of these methods, we need to minimize a contracted version of the objective function augmented by a regularization term in the form of Bregman divergence. We provide global convergence analysis for a general scheme admitting inexactness in solving the auxiliary subproblem. In the case of using for this purpose high-order Tensor Methods, we demonstrate an acceleration effect for both convex and uniformly convex composite objective function. Thus, our construction explains acceleration for methods of any order starting from one. The augmentation of the number of calls of oracle due to computing the contracted proximal steps, is limited by the logarithmic factor in the worst-case complexity bounds.

**Keywords:** convex optimization, proximal method, accelerated methods, global complexity bounds, high-order algorithms

2019/28

## Tensor methods for minimizing convex functions with Hölder continuous higher-order derivatives

Geovani Nunes Grapiglia and Yurii Nesterov

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In this paper we study  $p$ -order methods for unconstrained minimization of convex functions that are  $p$ -times differentiable ( $p \geq 2$ ) with  $\nu$ -Hölder continuous  $p$ th derivatives. We propose tensor schemes with and without acceleration. For the schemes without acceleration, we establish iteration complexity bounds of  $\mathcal{O}(\epsilon^{-1/(p+\nu)})$  for reducing the functional residual below a given  $\epsilon$  in  $(0,1)$ . Assuming that  $\nu$  is known, we obtain an improved complexity bound of  $\mathcal{O}(\epsilon^{-1/(p+\nu)})$  for the corresponding accelerated scheme. For the case in which  $\nu$  is unknown, we present a universal accelerated tensor scheme with iteration complexity of  $\mathcal{O}(\epsilon^{-p/((p+1)(p+\nu-1))})$ . A lower complexity bound of  $\mathcal{O}(\epsilon^{-2/3(p+\nu-2)})$  is also obtained for this problem class.

**Keywords:** unconstrained minimization, higher-order methods, tensor methods, Hölder condition, worst-case global complexity, bounds

2019/29

## Tensor methods for finding approximate stationary points of convex functions

Geovani Nunes Grapiglia and Yurii Nesterov

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In this paper we consider the problem of finding  $\epsilon$ -approximate stationary points of convex functions that are  $p$ -times differentiable with  $\nu$ -Hölder continuous  $p$ th derivatives. We present tensor methods with and without acceleration. Specifically, we show that the non-accelerated schemes take at most  $\mathcal{O}(\epsilon^{-1/(p+\nu-1)})$  iterations to reduce the norm of the gradient of the objective below a given  $\epsilon$  in  $(0,1)$ . For accelerated tensor schemes we establish improved complexity bounds of  $\mathcal{O}(\epsilon^{-(p+\nu)/((p+\nu-1)(p+\nu-1))})$  and  $\mathcal{O}(|\log(\epsilon)|\epsilon^{-1/(p+\nu)})$ , when the Hölder parameter  $\nu$  in  $[0,1]$  is known. For the case in which  $\nu$  is unknown, we obtain a bound of  $\mathcal{O}(\epsilon^{-(p+1)/((p+\nu-1)(p+2))})$  for a universal accelerated scheme. Finally, we also obtain a lower complexity bound of  $\mathcal{O}(\epsilon^{-2/3(p+\nu-2)})$  for finding  $\epsilon$ -approximate stationary points using  $p$ -order tensor methods.

**Keywords:** unconstrained minimization, high-order methods, tensor methods, Hölder condition, worst-case complexity

**2019/30**

## On inexact solution of auxiliary problems in tensor methods for convex optimization

Geovani Nunes Grapiglia and Yurii Nesterov

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In this paper we study the auxiliary problems that appear in  $p$ -order tensor methods for unconstrained minimization of convex functions with  $\nu$ -Hölder continuous  $p$ th derivatives. This type of auxiliary problems corresponds to the minimization of a  $(p+\nu)$ -order regularization of the  $p$ th order Taylor approximation of the objective. For the case  $p=3$ , we consider the use of Gradient Methods with Bregman distance. When the regularization parameter is sufficiently large, we prove that the referred methods take at most  $\mathcal{O}(\log(\varepsilon^{-1}))$  iterations to find either a suitable approximate stationary point of the tensor model or an  $\varepsilon$ -approximate stationary point of the original objective function.

**Keywords:** unconstrained minimization, high-order methods, tensor methods, Hölder condition, worst-case global complexity bounds

**2019/31**

## A dynamic conditional score model for the log correlation matrix

Christian M. Hafner and Linqi Wang

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This paper proposes a new model for the dynamics of correlation matrices, where the dynamics are driven by the likelihood score with respect to the matrix logarithm of the correlation matrix. In analogy to the exponential GARCH model for volatility, this transformation ensures that the correlation matrices remain positive definite, even in high dimensions. For the conditional distribution of returns we assume a student-t copula to explain the dependence structure and univariate student-t for the marginals with potentially different degrees of freedom. The separation into volatility and correlation parts allows two-step estimation, which facilitates estimation in high dimensions. We derive estimation theory for one-step and two-step estimation. In an application to a set of six asset indices including financial and alternative assets we show that the model performs well in terms of various diagnostics and specification tests.

**Keywords:** score, correlation, matrix logarithm, identification

**JEL codes:** C14, C43, Z11

**2019/32**

## Long term care insurance with state-dependent preferences

Philippe De Donder and Marie-Louise Leroux

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We study the demand for actuarially fair Long Term Care (LTC hereafter) insurance in a setting where autonomous agents only care for daily life consumption while dependent agents also care for LTC expenditures. We assume that dependency decreases the marginal utility of daily life consumption. We first obtain that some agents optimally choose not to insure themselves, while no agent wishes to buy complete insurance. We then show that the comparison of marginal utility of income (as opposed to consumption) across health states depends on (i) whether agents do buy LTC insurance at equilibrium or not, (ii) the comparison of the degree of risk aversion for consumption and for LTC expenditures, and (iii) the income level of agents. Our results then offer testable implications that can explain (i) why few people buy Long Term Care insurance and (ii) the discrepancies between various empirical works when measuring the extent of state-dependent preferences for LTC.

**Keywords:** long term care insurance puzzle, actuarially fair insurance, risk aversion

**JEL codes:** D11, I13