

## General Information

<b>Name of Research Unit:</b>	(MAT-LVT-297) Centro de Matemática e Aplicações - CMA
<b>Coordinator:</b>	Maria Luísa Martins Macedo de Faria Mascarenhas
<b>Main Scientific Domain:</b>	Matemática
<b>Other Subdomains:</b>	n/a

## Host Institutions

**Leading Host Institution:** Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

**Other Institutions Involved:**

## Objectives & Achievements

### Unit Description

CMA/UNL is located at Faculdade de Ciências e Tecnologia of Universidade Nova de Lisboa (FCT/UNL) at Caparica Campus and occupies two large rooms on the first floor of the Mathematics building.

CMA/UNL has 48 PhD active researchers and 39 collaborators, including PhD and MSc students, internal collaborators and collaborators from other units. The scientists at the center are organized into six research teams:

- Algebra;
- Statistical Inference;
- Distribution Theory;
- Differential Equations and Numerical Analysis;
- Operations Research;
- Actuarial and Financial Mathematics.

The Coordinator provides leadership and guidance for the development and implementation of research orientation in accordance with the decisions of the Scientific Committee (composed by all the active PhD members) and is assisted by an Executive Committee composed by four members. An External Advising Committee composed by six recognized high-level scientists follows the scientific activities of the CMA. The secretariat of the Department of Mathematics deals with the accounting and general administrative support.

CMA bylaw and membership requirement regulations are available in a written document, reviewed every year in order to contemplate the classification of the researchers according to productivity indicators. Each team is allocated its share of the funding in proportion to the number of its PhD active researchers.

For more information, see the CMA/UNL temporary web site at <http://sites.google.com/site/cmactun/>

### General Objectives

The objective of CMA/UNL is to promote high-level scientific research in the areas of pure and applied mathematics falling within the scope of the Department of Mathematics of FCT/UNL and its subsequent national and international projection.

Together with the support provided to traditional areas in the unit, like Actuarial, Financial Mathematics, Statistics and Operations Research, more abstract areas within the group of Algebra including Semigroup Theory, Ockham Algebras, Number Theory, Combinatory and Algebraic Topology, have been developed. On the other hand, some research oriented to Biomathematics and Material Science was initiated in the framework of Differential Equations and Numerical Analysis.

The interaction among the different research teams is steadily increasing, always preserving their own scientific strategy. Collaboration between the groups of Actuarial and Finance Mathematics, Statistical Inference and Distribution Theory already exists, and is growing up between Operations Research and Differential Equations and Numerical Analysis groups through optimization problems and numerical methods. To reinforce this direction and extended it to other disciplines inside and outside the FCT/UNL, weekly seminars are organized.

CMA/UNL is also involved in outreach activities such as the September Summer School (MathNova 2010) organized under topics related with Dynamic Systems, Games Theory, Combinatory, Topology, Operations Research, among others. This event is specifically directed to high school students and to university first cycle students and intends to show the fascinating side of these important research areas. The center will partially sponsor the event and aims to increase the number of BII scholarships in future FCT/MCTES calls.

Despite the enormous teaching charge, our researchers generally honor their commitments and developed an interesting scientific work. However, and in order to encourage good research practices and create adequate working conditions, we mention two goals:

- Promote, whenever it is possible, the reduction of the teaching charge for active researchers with outstanding scientific projects.
- Recover the scientific activity, through work plans, of investigators that have not met the productivity indicators referred in the unit description above.

### Main Achievements during the year of 2009



No. of Researchers Hired (Ciência Programme)	0,00	0,00	0,00	4,00	2,00	6,00
No. of Researchers (FTE)	23,00	32,00	42,00	49,00	48,00	
Training Masters (Master thesis completed)	1,00	5,00	6,00	6,00	5,00	23,00
Training PhDs (PhD thesis completed)	2,00	12,00	12,00	9,00	7,00	42,00

### Researchers Hired

Name	Start Date	End Date	Other Institution
Henry Liu	01-07-2009	30-06-2014	
Miguel dos Santos Fonseca	01-07-2009	30-06-2014	

### Technical Personnel Hired

Name	Start Date	End Date	Other Institution
No technical personnel found...			

### Additional Comments

#### Additional Comments

Two of the selected candidates in Science 2008, in a total of four, did not formalized their contracts. The number mentioned in 2009 corresponds to those who formalized the contract.

### Research Groups

Reference	Title / Principal Investigator
RG-LVT-297-1846	<u>Algebra</u> (Maria Helena Coutinho Gomes de Almeida Santos)
RG-LVT-297-1847	<u>Statistical Inference</u> (João Tiago Praça Nunes Mexia)
RG-LVT-297-1848	<u>Distribution Theory</u> (Carlos Manuel Agra Coelho)
RG-LVT-297-1849	<u>Differential Equations and Numerical Analysis</u> (Maria Luísa Martins Macedo de Faria Mascarenhas)
RG-LVT-297-1850	<u>Operational Research</u> (Paula Alexandra da Costa Amaral Jorge)
RG-LVT-297-1852	<u>Actuarial and Financial Mathematics</u> (Manuel Leote Tavares Ingles Esquivel)

## Group Description

<b>Title of Research Group:</b>	(RG-LVT-297-1846) Algebra
<b>Principal Investigator:</b>	Maria Helena Coutinho Gomes de Almeida Santos
<b>Main Scientific Domain:</b>	Matemática
<b>Group Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

## Funding, source, dates

### Funding, source, dates

PTDC/MAT/098317/2008, FCT/MCTES  
 Approved in 2009  
 From February 2010 to February 2013.  
 Principal Investigator: Goncalo Tabuada  
 Total Funding: 53740 euros.

## Objectives & Achievements

### Objectives

Prosecute ongoing research on the following topics.

Generalized sumsets problems.

Repetitions in combinatorics on words.

Construction of a precise functor relating Voevodsky's mixed motives with Kontsevich's non-commutative mixed motives. This functor should be the starting point in the proof of Orlov's conjectures relating derived categories with mixed motives.

Research projects in graph theory.

Let  $G$  and  $H$  be two graphs and  $c$  a positive number. Each edge of  $G$  has weight 1 and each  $H$ -subgraph of  $G$  has weight  $c$ . An  $H,c$ -decomposition of  $G$  is a partition of the edge set of  $G$  such that each part is either a single edge or a copy of  $H$  and the weight of the decomposition is the sum of the weights of each element in the decomposition. Let  $f(G,H,c)$  be the smallest possible weight in an  $H,c$ -decomposition of  $G$ . During 2009 was studied the problem of finding the smallest value  $f(n,H,c)$  such that any graph of order  $n$  admits an  $H,c$ -decomposition with weight at most  $f(n,H,c)$ .

Relation between perturbing the  $i$ th-diagonal entry of an Hermitian matrix  $A$  and extracting the principal submatrix  $A(i)$  from  $A$  with respect to the possible changes in multiplicity of a given eigenvalue.

Minimal rank of matrices associated with a graph and the equivalence class graph. Properties of the equivalence class graph and particularly cases for that we have the minimum rank of the matrix equal to the order of the equivalence class graph.

Strong endomorphism kernel property in Ockham algebras.

The lattice of subalgebras of an Ockham algebra.

Ordered regular Semigroups.

### Main Achievements

It was given the first conceptual characterization of Quillen's higher K-theory since Quillen's foundational work in the 70's.

Development of a theory of non-commutative motives as it was conjectured by Drinfeld and Kontsevich. These results motivated an invitation to talk in the Topology Seminar of the Massachusetts Institute of Technology, on the 29 March 2010 (<http://math.mit.edu/topology/>).

It was studied the weighted decomposition problem for the special case when  $H$  is a complete graph and obtained some preliminary results for this special case.

It was submitted a paper in which we give a complete description of the relation between perturbing the  $i$ th-diagonal entry of an Hermitian matrix  $A$  and extracting the principal submatrix  $A(i)$  from  $A$  with respect to the possible changes in multiplicity of a given eigenvalue. We also generalize and improve prior work about Hermitian matrices whose graph is a given tree.

This is a joint work with Charles R. Johnson, The College of William and Mary, Williamsburg, VA, USA and António Leal Duarte, Universidade de Coimbra, Portugal.

Investigation concerning the minimal rank of matrices associated with a graph and its equivalence class graph was continued. In collaboration with Maria do Rosário Fernandes a characterization of the graphs which are different from its equivalence class graph was obtained. The graphs whose associated matrix has minimum rank equal to the order of its equivalence class graph has also been studied.

An endomorphism on a algebra  $A$  is said to be strong if it is compatible with every congruence on  $A$  and  $A$  is said to have the strong endomorphism kernel property if every congruence different from the universal congruence is the kernel of a strong endomorphism on  $A$ . We consider this property in the context of Ockham algebras. In particular, for those MS-algebras that have this property we describe the structure of their dual space in terms

of 1-point compactifications of discrete spaces.

The description of all amenable orders definable on a regular semigroup with a quasi-ideal inverse transversal.

## Group Productivity

### Publications in peer review Journals

1. Blyth, T.S., Almeida Santos, M.H., On Inverse Transversals of Ordered Regular Semigroups, *Communications in Algebra*, 37, (2009), 2200-2212. (IF: 0.337)
2. Blyth, T.S., Almeida Santos, M.H., On Ordered E-inversive semigroups, *Semigroup Forum*, 78, (2009), 511-527. (IF: 0.493)
3. Cilleruelo, J., Vinuesa, C., Silva, M., A Sumset problem. *Journal of Combinatorics and Number Theory* (in print).
4. Liu, H., Morris, H., Prince, N., Highly connected monochromatic subgraphs of multicoloured graphs, *J Graph Theory*, 61(1) (2009), 22-44. (IF: 0.655)
5. Liu, H., Person, Y., Highly connected coloured subgraphs via the regularity lemma, *Discrete Math*, 309(21) (2009), 6277-6287. (IF: 0.502)
6. Martins, J.F., The fundamental crossed module of the complement of a knotted surface. *Trans. Amer. Math. Soc.* 361 (2009), no. 9, 4593--4630. (IF: 1,014)
7. Martins, J.F.; Miković, Aleksandar Spin foam perturbation theory for three-dimensional quantum gravity. *Comm. Math. Phys.* 288 (2009), no. 2, 745--772. (IF: 2,075 )
8. Tabuada, G., Homotopy theory of spectral categories. *Advances in Mathematics*, 221 (2009), no.4, 1122-1143. (IF: 1.280)
9. Tabuada, G., Homotopy theory of well-generated algebraic triangulated categories, *Journal of K-theory*, 3 (2009), no.1 53-75. (ISI list but no IF)
10. Tabuada, G., Postnikov towers,  $\mathbb{k}$ -invariants and obstruction theory for dg categories. *J. Algebra* 321 (2009), no. 12, 3850-3877. (IF: 0,630)
11. Tabuada, G., Non-commutative André-Quillen cohomology for differential graded categories. *J. Algebra* 321 (2009), no. 10, 2926-2942. (IF: 0,630)

We also mention two 2008 publications that were not included in the CMA Report 2008:

1. Kao, J.-Y., Rampersad, N., Shallit, J., Silva, M., Words avoiding repetitions in arithmetic progressions. *Theoret. Comput. Sci.* 391 (2008), no. 1-2, 126--137.
2. Tabuada, G., Higher K-theory via universal invariants. *Duke Math. Journal*, 145 (2008), no.1, 121-206. (IF: 1.494)

### Internationalization

Several joint publications as stated above.

Separate joint research projects in graph theory with Shinya Fujita, and Yury Person.

Joint research with Charles Johnson, Jui-Yi Kao, Narad Rampersad, Jeffrey Shallit, Javier Cilleruelo, Carlos Vinuesa.

International invited talks:

1. Matrix invariants of spectral categories. Topology seminar, Stanford University, USA. May 2009.
2. Non-connective K-theory via universal invariants. Series of lectures at the algebra seminar, University of California at Los Angeles, USA. April/May 2009.

Attended Courses:

1. "Fourier Analysis and Matrix Theory" with Professor Rajendra Bathia, Indian Statistical Institute, new Delhi, held at the CELC, Portugal, on May 25, 28, and June 1,4, 2009.
2. "Combinatorial Aspects of Permutations and Words" with Professor Marilena Barnabei, Università di Bologna, Italia, held at the CELC, Portugal, June 17,18, 2009. "Algebra and Logic", held at the Faculdade de Ciências da Universidade de Lisboa, Portugal on June 19, 2009.

### Future Research

#### Objectives

Focus on generalized Sumset problems as studied in

J. Cilleruelo, C. Vinuesa, M. Silva, A Sumset problem. *Journal of Combinatorics and Number Theory*,

trying to obtain the best possible lower bound for the number of elements for any linear form. We also characterize the structure of the minimal sets.

The relation between repetitions in infinite words and problems in additive number theory will be also an important subject of research.

The goal in a near future is the construction of a precise functor relating Voevodsky's mixed motives with Kontsevich's non-commutative mixed motives. This functor should be the starting point in the proof of Orlov's conjectures relating derived categories with mixed motives.

Participation in the Topology Seminar of the Massachusetts Institute of Technology, on the 29 March 2010, with a talk entitled "Non-comutative motives" (<http://math.mit.edu/topology/>).

Given a fixed graph  $H$ , a graph  $G$  of order  $n$  and a 2-edge-coloring of the edges of  $G$ , an edge-monochromatic  $H$ -decomposition of  $G$  is a partition of the edge set of  $G$  such that each part is either a single edge or a monochromatic copy of  $H$ . Let  $M(G,H,2)$  be the smallest value such that for any 2-edge-coloring of  $G$  there exists an edge-monochromatic  $H$ -decomposition of  $G$  with at most  $M(G,H,2)$  elements. The goal is to find the value of the function  $M(n,H,2)$ , which is the smallest number such that for any graph  $G$  of order  $n$  and any 2-edge-coloring of  $G$  admits an edge-monochromatic  $H$ -decomposition with at most  $M(n,H,2)$  elements. The first interesting open problem is the case  $H$  is the complete graph of order 3. In 2010 the research goals are the study of the weighted decomposition problem for any graph  $H$  and the study of monochromatic  $H$ -decompositions of graphs for the special case when  $H$  is a triangle.

To solve many problems in graph theory namely several problems which concern decomposing a graph into copies of a given graph and edges, a problem which concerns partitioning the vertex set of a vertex coloured graph. And problems which utilise Szemerédi's regularity lemma.

To study several problems concerning eigenvalues. To find an algorithm to compute the maximum multiplicity for an eigenvalue among Hermitian matrices whose pattern is defined by a given graph. The solution is known when the graph is a tree. To determine lists of multiplicities for some classes of trees. To solve the Inverse Eigenvalue Problem for some classes of tree. To investigate the existence/construction of Hermitian matrices with some graph and some list of multiplicities. To determine the relation between the number of eigenvalues (of a matrix whose graph is a tree) having multiplicity one and the structure of the tree. To determine trees for which the maximum multiplicity implies the minimum number of distinct eigenvalues.

In addition to continuing research on the strong endomorphism kernel property we aim to develop research on the lattice of subalgebras of an Ockham algebra.

To study relations between orders defined in a semigroup  $S$  and inverse transversals of  $S$ .

#### **Funding, source, dates**

PTDC/MAT/098317/2008, FCT/MCTES.

Approved in 2009.

From February 2010 to February 2013.

Principal Investigator: Goncalo Tabuada

Total Funding: 53740 euros.

PTDC/MAT/113207/2009, FCT/MCTES

Submitted in 2009

H-Decompositions of Graphs: Two new problems

Principal Investigator: Teresa Maria Jerónimo de Sousa

Total Funding: 51120,00 euros.

## Group Description

<b>Title of Research Group:</b>	(RG-LVT-297-1847) Statistical Inference
<b>Principal Investigator:</b>	João Tiago Praça Nunes Mexia
<b>Main Scientific Domain:</b>	Matemática
<b>Group Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

## Funding, source, dates

### Funding, source, dates

PTDC/MAT/69850/2007, FCT/MCTES

Linear Mixed Models

Limit date: 13/5/2010

Principal Investigator: J.T. Mexia

Total funding: 14.899,00 euros

Existing funding: approximately 5.959,60 euros

PTDC/AGR-AAM/71649/2006 FCT/MCTES

Droughts Risk Management: Identification, Monitoring, Characterisation, Prediction and Mitigation

Limit date: 30-10-2010

Principal Investigator: L.A. Santos Pereira

Total funding: 52.992,00 euros

Existing funding: approximately 21.196,80 euros

PTDC/AGR-CFL/64146/2006, FCT/MCTES(\*)

Decision support tools for integrating fire and forest management planning

Limit date: 30-11-2010

Principal Investigator: J.G. Martins Dias Calvão Borges

(\*) This project does not include CMA/UNL, although the CMA member J.T. Mexia integrates the project team.

## Objectives & Achievements

### Objectives

We intend to extend our results on orthogonal models considering:

- Models with COBS (Commutative Orthogonal Block Structure). These models have as variance-covariance matrix a linear combination of pairwise orthogonal known orthogonal projection matrices that commute with the orthogonal projection matrix on the space spanned by the mean vector.
- L extensions, that is models written as  $Y=LX+e$ , where the matrix L has linearly independent column vectors and X may correspond to an orthogonal model or a model with COBS.

On the applications side we intend to:

- Continue our studies on JRA. We have received a very good data set from tea Check Republic, which will enable us to deepen the analysis of the environmental index as a productivity measure.
- Apply risk Theory to forest fires.
- Continue the applications of Statistical Modeling for Drought Management.
- Moreover eight PhD are expected to be completed under the supervision of the research line members.

### Main Achievements

On the theoretical side we were able:

- to extend, see Jesus et al., confounding and factorial replicates to models whose factors had whatever number of levels;
- to obtain, see Mexia & Oliveira, approximate normal distributions for a large class of statistics in the normal case when the variation coefficients of the observations;
- to apply L extensions to multiple regression designs to overcome the usual restriction of requiring all regressions to have the same model matrix, see Moreira & Mexia.
- to estimate in models with Commutative Orthogonal Block Structure (COBS), see Carvalho, Mexia & Oliveira.
- to obtain least squares and generalized least squares in models with orthogonal block structure, see Fonseca, Mexia & Zmyslony.

On the applications side we:

- obtained good algorithms, see Pereira & Mexia, for Joint Regression Analysis;
- applied successfully biregressional modeling to heavy metal electroremediation, see Lima, Rodrigues & Mexia.

## Group Productivity

### Publications in peer review Journals

1. Covas R., Zmyslony R., Mexia J.T., Lattices of Jordan algebras. *Linear Algebra and Its Applications* (in print) (IF: 0.878).
2. Fonseca M., Mexia J. T., Zmyslony R., Least squares and generalized least squares in models with orthogonal block structure. *Journal of Statistical Planning and Inference* 140 (2009) (5): 1346-1352 (IF: 0.679).
3. Jesus V., Fonseca M., Mexia J.T., Zmyslony R., Binary operations and canonical forms for factorial and related models: *Linear Algebra and its Applications*, 430 (2009): 2781–2797 (IF: 0.878).
4. Lima A.T., Rodrigues P.C., Mexia J.T., Heavy metal migration during electroremediation of fly ash from different wastes-Modelling. *Journal of Hazardous Materials* 175 (2009): 366-371. (IF: 2.975).
5. Mexia J.T., Oliveira M.M., Asymptotic linearity and limit distributions, approximations. *Journal of Statistical Planning and Inference*, (in print) (IF: 0.679).
6. Moreira E. E, Mexia J. T., L models and multiple regression designs. *Statistical Papers*, 50 (2009) 869-885. (IF: 0.278).
7. Pereira, D. G., Mexia, J. T., Comparing double minimization and zigzag algorithms in Joint Regression Analysis: the complete case. *Journal of Statistical Computation and Simulation*, 80 (2009), 133-141. (IF: 0.353)
8. Rodrigues P.C., Lima, A.T., Analysis of a European Union election using principal component analysis. *Statistical Papers* 50 (2009) 895-904. (IF: 0.278).
9. Carvalho F., Mexia J. T., Oliveira M. M., Estimation in Models with Commutative Orthogonal Block Structure: *Journal of Statistical Theory and Practice*, 3 (2009), 2, 525-535.
10. da Silva J.L., A Note on the Strong Consistency of Least Squares Estimates. *Discussiones Mathematicae Probability and Statistics*, 29 (in print).
11. da Silva J.L., Oliveira A.M., On the matrix form of Kronecker lemma. *Discussiones Mathematicae Probability and Statistics*, 29 (in print).
12. Guerreiro G., Predictions for evolution of Pension Funds Beneficiaries. *Discussiones Mathematicae Probability and Statistics*, 29 (in print).
13. Jesus V., Mexia J.T., Rodrigues P.C., Binary operations on orthogonal models, application to prime basis factorials and fractional replicates. *Journal of Statistical Theory and Practice* 3 (2009): 505-521.
14. Jesus V., Oliveira S., Mexia J., Binary Operations on Prime Basis Factorials. *Biometrical Letters*, Vol 46 (2009) (1), pp. 1-14.
15. Martins A., Pinto I., Cardoso M., Using Multidimensional Unfolding in Plant Breeding Programs. *Biometrical Letters*, Vol. 46 (2009), No. 1, 55-70.
16. Mateus A., Tomé M., A dominant height growth model for eucalyptus plantations in Portugal. *Discussiones Mathematicae Probability and Statistics*, 29 (in print).
17. Sequeira I. J., Nunes S., Mexia J.T., Relating the incidences of AIDS and opportunistic diseases in the European Union. *Biometrical Letters*, Vol. 46 (2009), No. 1, 15-25.
18. Ramos L., Sample Partitioning Estimation for Ergodic Diffusions: Application to Ornstein-Uhlenbeck Diffusion. *Discussiones Mathematicae Probability and Statistics*, 29 (in print).

### Other publications International

1. Esquivel M., Mexia J. T., da Silva J. L., Ramos L. P. C., Some asymptotic expansions and distribution approximations outside a CLT context. *Proceedings of 6th St. Petersburg Workshop on Simulation*.
2. Ferreira D., Ferreira S., Nunes C., Mexia J.T., Adjustment of Normal Mixed Models Through Triple Minimization. *INTERSTAT – Statistics on the Internet*, ISSN 1941-689X.
3. Guerreiro G.R., Mexia J.T.: Stochastic Vortices, An application to Pension Funds, *Proceedings of the 5th Conference in Actuarial Science and Finance*, Samos, Greece, 83-97
4. Martins A., Cardoso M., Pinto I., Multidimensional Unfolding and the use of input alternative scales. *Journal of Targeting, Measurement and Analysis for Marketing*. Issue 17: 195-204, advance online publication, June 29, 2009; doi:10.1057/jt.2009.10
5. Rodrigues P.C., Mejza S., Mexia, J.T., Structuring Genotype x Environment Interaction: an Overview. *Bulletin of Plant Breeding and Acclimatization Institute* 250:225–236.

### Book Chapters

1. Pereira D.G., Rodrigues P.C., Oliveira A., Mexia J.T., Joint Regression Analysis and Completed Joint Regression Analysis. Chapter 7 In: *Plant Breeding*. Huttunen, N. and Sinisalo, T., Eds. Nova Science Publishers, Inc. ISBN: 978-1-61668-211-8.

### Other publications National

National oral communications

1. de Carvalho M. , Rodrigues P.C., Método de Imputação Recorrente: Análise Espectral Singular com Valores Omissos. XVII Congresso Anual da Sociedade Portuguesa de Estatística, FCT-UNL, Sesimbra (Prize SPE 2009).
2. de Carvalho M. , Rodrigues P.C., Métodos de análise espectral singular. XVII Congresso Anual da Sociedade Portuguesa de Estatística, FCT-UNL, Sesimbra.
3. Fonseca M., Testes de rácio de verosimilhança com restrições e hipóteses na fronteira. XVII Congresso Anual da Sociedade Portuguesa de Estatística, FCT-UNL, Sesimbra.
4. Guerreiro G.R., Mexia J.T., Stochastic Vortices: An application to Bonus Malus. XVII Congresso da Sociedade Portuguesa de Estatística, FCT-UNL, Sesimbra.
5. Moreira E. E., Mexia J. T., Pereira L. S., Análise de diferenças nas transições entre classes de seca utilizando uma ANOVA adaptada. XVII Congresso Anual da Sociedade Portuguesa de Estatística, FCT-UNL, Sesimbra.
6. Pinto I., Caracterização de Soluções Degeneradas em Multidimensional Unfolding. XVII Congresso Anual da Sociedade Portuguesa de Estatística, FCT-UNL, Sesimbra.
7. Roçadas C., Cadeias de Markov: Aplicação ao Sector Bancário. Workshop em Estatística pela Jubilação do Professor João Tiago Mexia, FCT-UNL, Caparica.

### **Master and Ph.D. thesis completed**

#### Ph.D. Thesis

1. Areia, Aníbal. Séries Emparelhadas de Estudos: Estrutura Comum e Inferência. Departamento de Matemática. Universidade de Évora.
2. Fernandes, Célia. Modelos com cruzamento e aninhamento em escada. Departamento de Matemática. Universidade da Beira Interior
3. Guerreiro, Gracinda. Populações Sujeitas a Reclassificações Periódicas. Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa.
4. Miguel Brás de Carvalho, "Extremum Estimators and Stochastic Optimization Methods" at the FCT/UNL, approved by unanimity.
5. Ramos, Paulo. Interação entre factores aninhados. Departamento de Matemática. Universidade da Beira Interior
6. Roçadas, Cláudia. Populações Emparelhadas com ReClassificação Periódica; Aplicação a uma Carteira de Clientes. Universidade Aberta, Lisboa.
7. Sequeira, Inês. Modelação Estatística das Co-Infecções da SIDA em Países da União Europeia. Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa.

### **Organization of conferences**

SPE2009-XVII Congresso Anual da Sociedade Portuguesa de Estatística, FCT-UNL, Sesimbra.

The members of the group João Tiago Mexia, João Lita da Silva, Gracinda Guerreiro and Luís Ramos integrated the Organizing Local Committee.

### **Internationalization**

- Invited stay in CMA of Professor Roman Zmyslony from Faculty of Mathematics, Computer Sciences and Econometrics, University of Zielona Góra, Poland, to collaborative work with the members of the line.
- Invited stay in CMA of Professor Stanisław Mejza from Poznan University of Life Sciences, Poland, to collaborative work with the members of the line.
- Invited stay in CMA of Professor Bimal Sinha from Department of Mathematics & Statistics, University of Maryland, Baltimore County, USA, to collaborative work with the members of the line.
- Participation of researchers of the line in MAT-TRIAD 2009 conference in Bedlewo, Poland.

Oral communication in International conferences: 14

Posters in international conferences: 1

### **Future Research**

#### **Objectives**

We intend to:

- develop the theory of models using stair nesting. There, the number of treatments will be the same of the number of levels. We also intend to study the crossing and nesting of these models.
- continue to apply the delta method to statistics given by asymptotically linear functions. This class contains low degree polynomials, thus covering most widely used statistics.
- continue developing triple minimization algorithms to obtain maximum likelihood estimators for normal non orthogonal models. The first two phases reduce the estimation to the relative variance components, which are the orthogonal variance components divided by their sum, thus greatly reducing the dimension of the problem.
- Continue with statistical applications to drought management, namely:
  - searching in Portugal for homogeneous regions in terms of drought risk using clustering of loglinear models through Likelihood Ratio Tests (LRT);
  - investigate if the drought occurrence is aggravating by studying long time series of drought indices through an ANOVA-like inference.

**Funding, source, dates**

PTDC/MAT/69850/2007, FCT/MCTES

Linear Mixed Models

Limit date: 13/5/2010

Principal Investigator: J.T. Mexia

Total funding: 14.899,00 euros

Existing funding: approximately 5.959,60 euros

PTDC/AGR-AAM/71649/2006 FCT/MCTES

Droughts Risk Management: Identification, Monitoring, Characterisation, Prediction and Mitigation

Limit date: 30-10-2010

Principal Investigator: L.A. Santos Pereira

Total funding: 52.992,00 euros

Existing funding: approximately 21.196,80 euros

PTDC/AGR-CFL/64146/2006, FCT/MCTES(\*)

Decision support tools for integrating fire and forest management planning

Limit date: 30-11-2010

Principal Investigator: J.G. Martins Dias Calvão Borges

(\*) This project does not include CMA/UNL, although the CMA member J.T. Mexia integrates the project team.

## Group Description

<b>Title of Research Group:</b>	(RG-LVT-297-1848) Distribution Theory
<b>Principal Investigator:</b>	Carlos Manuel Agra Coelho
<b>Main Scientific Domain:</b>	Matemática
<b>Group Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

## Funding, source, dates

### Funding, source, dates

Project PTDC/AGR-AAM/71649/2006, FCT/MCTES

Droughts Risk Management: Identification, Monitoring, Characterisation, Prediction and Mitigation' (2007-2010)

Principal Investigator: Luís Santos Pereira, Instituto Superior de Agronomia/UTL.

Funding: approximately 2000 euros/year

Project POCI/CLI/60006/2004 and PPCDT/CLI/60006/2004, FCT/MCTES

Linking Water and Carbon Cycles in Eucalypt Plantations' (2005-2009)

Principal Investigator: Abel Martins Rodrigues, Instituto Nacional de Recursos Biológicos, I.P. (INRB/MADRP)

Funding: approximately 1000 euros/year

FCT/PPCDT/ MAT/58876/2004, FCT/MCTES

ERAS — EXTREMES, RISK, SAFETY and the ENVIRONMENT" (2007-2009)

Principal Investigator: M. Ivette Gomes, Department of Statistics and Operations Research from Universidade de Lisboa

Funding: approximately 500 euros/year

## Objectives & Achievements

### Objectives

I - In the area of the near-exact distributions the objectives were:

a) continuation of the development of near-exact distributions for statistics used in tests of complex structures in variance-covariance matrices, as the ones for the block-matrix sphericity and the block-scalar sphericity tests for one or several populations and the multiple sphericity test for several populations, obtained from the decomposition of the corresponding null hypotheses into sequences of nested, more elementary and conditionally independent hypotheses, allowing this way for the building of near-exact characteristic functions from adequate decompositions of the characteristic functions of the statistics corresponding to those elementary hypotheses;

b) continuation of the development of a general approach for the development of l.r.t statistics and their near-exact distributions for tests used in Multivariate Statistics whose null hypotheses being too complex may be split into more elementary and conditionally independent hypotheses, which may lead to a more general test which may include both extended sphericity test families referenced above;

c) in connection with b) above, we intend to develop likelihood ratio statistics to test the error covariance structure in mixed models and obtain near-exact distributions for such statistics since their exact distributions are essentially intractable and it does not seem possible to develop accurate enough asymptotic distributions by using the usual approaches.

II - In the area of exact distributions, the objectives were:

a) conclusion of the development of simple expressions for the distribution of the product of independent Gamma r.v.'s and of the Generalized Variance, preferably under a form that may be adequate to obtain near-exact distributions for l.r.t. statistics based on the Generalized Variance;

b) conclusion of the studies on the relation of the distribution of products of powers of independent Uniform random variables with the distribution of some statistics.

III - In the area of extreme-value distributions, the objectives were:

- continuation of the studies on estimation of parameters and their bias in heavy tailed models as the the tail index and high quantiles (in collaboration with Prof. Ivette Gomes from the Department of Statistics of the University of Lisbon).

### Main Achievements

Mainly all objectives were achieved. Many near-exact distributions were and are being developed based on the technique of decomposition of the null hypothesis into conditionally independent hypotheses. A few technical reports were produced and submitted for publication.

Some further results were obtained concerning the exact distribution of the product of independent generalized Gamma-ratio random variables, namely concerning the non-central case and the development of some near-exact distributions.

In the area of extreme value theory the results obtained originated a few papers.

## Group Productivity

## Publications in peer review Journals

1. Coelho, C. A., Marques, F. J., The advantage of decomposing elaborate hypotheses on covariance matrices into conditionally independent hypotheses in building near-exact distributions for the test statistics, *Linear Algebra and its Applications*, 430 (2009), 2592-2606. (IF: 0.878)
2. Caeiro, F., Gomes, M.I., Semi-parametric second-order reduced-bias high quantile estimation. *Test*, 18 (2009).(2), 392-413. (IF: 0.930)
3. Caeiro, F., Gomes, M.I., Henriques Rodrigues, L., Reduced-bias tail index estimators under a third order framework. *Communications in Statistics - Theory and Methods*, 38 (2009) (7), 1019-1040. (IF: 0.324)
4. Gomes, M.I., Pestana, D., Caeiro F., A note on the asymptotic variance at optimal levels of a bias-corrected Hill estimator. *Statistics and Probability Letters*, 79 (2009) (3), 295-303. (IF: 0.445)

## Other publications National

1. Marques, F. J., Coelho, C. A., O teste de esfericidade para várias amostras Como usar a decomposição da hipótese nula na construção de aproximações quase-exactas para a estatística de teste. *Actas do XVI Congresso Anual da Sociedade Portuguesa de Estatística - "Da Teoria à Prática"*, 2009, 417-428.
2. Caeiro, F., Gomes, M.I., Pestana, D., Alguns resultados adicionais sobre a variância de um estimador de viés reduzido do índice de cauda. *Actas do XVI Congresso Anual da Sociedade Portuguesa de Estatística (2009) - "Da Teoria à Prática"*, 167-178.

## Organization of conferences

- Three of the team members were involved in the organization of the "XVII Congresso da Sociedade Portuguesa de Estatística"
- Two team members took part in the Scientific Board of the 4th International Workshop on Statistics, Mathematics and Computation, 09 – 10 Novembro, Fundação Calouste Gulbenkian, Lisboa, Portugal, 2009, organized by Universidade Aberta.
- Two of the team members were in the organization of a two-day Workshop to commemorate the Jubilee of Professor J. Tiago Mexia.

## Internationalization

Part of the research done in the area of near-exact distributions is now done in conjunction with Professor Barry C. Arnold from the Statistics Department of the University of California at Riverside.

## Future Research

### Objectives

In the area of near-exact distributions we will go on developing near-exact distributions for several other statistics based on the decomposition of the null hypothesis into conditionally independent hypotheses and we will start the development of near-exact distributions based on the expansion of the distribution of adequate random variables as mixtures, namely on the expansion of the Logbeta distribution as an infinite mixture of Gamma distributions. This latter technique will allow us to develop near-exact distributions with a pre-demanded upper bound on the error, where this 'error' is taken as the maximum of the absolute value of the difference between the exact and the near-exact cumulative distribution function, for the whole support of the random variable. This upper bound is obtained from an expression for the distance between two distributions, developed by the team members, based on the associated characteristic functions or Mellin transforms. The objectives also extend to the preparation of a monograph on near-exact distributions.

In the area of exact distributions one of the objectives is to further develop manageable forms of the exact distribution for the product of F and generalized Gamma-ratio random variables, together with the distribution for the product of the non-central versions of these distributions and also, given the complexity of the exact distributions, together with the development of adequate near-exact distributions. This is a work that will build on some earlier work already developed together with a researcher of the sub-project "Statistical Inference" of CMA. The new results and the overall final results are intended to be published as a monograph.

In the area of extreme value theory the research work will continue to be centered on the estimation of parameters and their bias in heavy tailed models, with emphasis on reduced bias estimation of such parameters.

### Funding, source, dates

PTDC/MAT/103090/2008, FCT/MCTES

Submitted in 2009

Testing the error covariance structure in Linear and Nonlinear Models - Development of a test statistic and its exact and near-exact distributions

Principal Investigator: Carlos A. Coelho.

Total Funding:

## Group Description

<b>Title of Research Group:</b>	(RG-LVT-297-1849) Differential Equations and Numerical Analysis
<b>Principal Investigator:</b>	Maria Luísa Martins Macedo de Faria Mascarenhas
<b>Main Scientific Domain:</b>	Matemática
<b>Group Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

## Funding, source, dates

### Funding, source, dates

1. Research project ANR-07-CIS7-007-03, funded by Agence Nationale de la Recherche, France  
Simulation Haute Performance du Stockage Géologique de CO<sub>2</sub>

Participating Investigator: F. Caetano

2. Project PTDC/MAT/66426/2006. Coordinator: F.A.C.C. Chalub

Total funding: 49.000 euros (2007-2010)

3. CMU-PT/0019/2007. Coordinator: F.A.C.C. Chalub

Total funding: 41.248 euros (2007-2011)

4. Bilateral Agreement Portugal-Brazil. Joint Coordinator: F.A.C.C. Chalub

Total funding: 10.000 euros (2009-2010)

5. UT Austin/MAT/0035/2008. Participating Investigators: F.A.C.C. Chalub, F. Oliveira

Total funding: 100.000 euros (2009–2013)

6. PTDC/FIS/70973/2006. Participating Investigators: F.A.C.C. Chalub

Total funding: 59.000 euros (2008-2011)

7. POCI/PPCDT/MAT/60587/2004. Coordinator: M.L. Mascarenhas

Total funding: 31 500 Euros ( 2005-2009)

8. PTDC/MAT/68615/2006. Coordinator: Filipe Oliveira

Total funding: 20.000 euros (2007-2010)

9. Bilateral Agreement Portugal-Brazil.

Approved in 2009.

Joint coordinator: Filipe Oliveira

Total funding for the first year (2010): 5.000 euros

## Objectives & Achievements

### Objectives

The group carried out its research on the following topics:

Calculus of Variations and Optimization; Conservation Laws; Dynamical Systems; Factorization of Boundary Value Problems; Kinetic Models; Mathematical Modeling and Functional Analysis

More specifically:

F. Caetano developed optimized domain decomposition algorithms of Schwarz waveform relaxation (SWR) type for non-linear reaction-diffusion equations.

F. Chalub's work was concerned with the mathematical study of different models that are currently used in life sciences, and the application of evolutionary game theory as a mathematical modeling tool of different biological phenomena.

P.J. Doutor studied the generalization of the classical thermodynamic formalism for nonadditive sequences, and characterization of the dimension spectra of Hölder continuous functions.

J. M. Gomes went on studying the geometrical properties of level states of ground-state solutions, i.e. of the minimizers of the Dirichlet integral under a volume constraint.

B. Louro, M. C. Soares and M. Orey went on developing the invariant embedding method for more general elliptic operators stated in more general domains.

R. Martins carried out his work on synchronization phenomena in linearly coupled non-identical and non-autonomous oscillators. He continued the study of models formulated within the framework of the theory of liquid crystals in the presence of an alternating shear and magnetic fields.

M. L. Mascarenhas and R. Ferreira proceeded the study of the derivation of the 1D and 2D theories from 3D models. Specifically, a mathematical approach to wave propagation in thin oscillating media, was undertaken. M. L. Mascarenhas also collaborated with L. Trabucho from CMAF and G.

Bouchitté from Univ. de Toulon et du Var, regarding spectral problems in thin domains.

Rita Ferreira also proceeded the study of relaxation of first and second order problems with linear growth, obtaining partial results in the scope of her Ph.D. thesis.

F. Oliveira investigated the construction of kinetic models for gases with particles undergoing both elastic and chemical shocks. He was also interested in the analysis of dispersive nonlinear equations: derivation of local and global well-posedness results for the Davey-Stewartson system and the Zakharov-Rubenchik system, and study of existence and stability of solitary waves for systems of Benney type.

A. M. Ribeiro concluded some works with E. Zappale, on relaxation problems related to image modelling.

Strong collaboration will continue with CMAF and CFTC, from Universidade de Lisboa, with CAMGSD, from IST, and with CMAT from Universidade do Minho. The interaction with Physics and Engineering departments inside FCT-UNL remains one of our main goals.

Other goals:

1. Participation in the international programs in Mathematics with CMU and Austin-Texas.
2. Participation in Club Math (<http://ferrari.dmat.fct.unl.pt/clubemath/>), a strategy to attract young people into Mathematics.

## Main Achievements

Our team produced 16 publications in high level peer-reviewed journals.

Several of these results were communicated in national and international conferences.

Besides the active participation in CMU-Portugal and in Austin Texas-Portugal Programs, an other important achievement was the preparation of the joint doctoral program in association with Faculdade de Ciências, Universidade de Lisboa.

The weekly scientific seminar enabled us to receive national and international specialists in the area of Differential Equations and Numerical Analysis and provided a place for discussion and scientific exchange with our colleagues from other departments of the Faculdade de Ciências e Tecnologia.

In June a Mini-Journey on PDEs, was organized with the presence of G. Bouchitté, from the University of Toulon and of Bernard Dacorogna, from the École Polytechnique Fédérale de Lausanne.

As in the previous year, the team was involved in important outreach activities such as Directive board of the Sociedade Portuguesa de Matemática (F. Oliveira), Committee of Applied Mathematics of the European Mathematical Society (M. L. Mascarenhas), Programa Novos Talentos em Matemática da Fundação Calouste Gulbenkian (F. Oliveira), Organization of Club Math (<http://ferrari.dmat.fct.unl.pt/clubemath/>) dedicated to young students from Ensino Básico e Secundário (M. C. Soares) and several other scientific divulgation events.

Specific achievements

F. Caetano – A Schwarz Waveform Relaxation algorithm with non-linear transmission conditions of Robin and second order type is applied to a 2D and 3D semi-linear reaction diffusion equation. Convergence of the algorithm is proved and numerical implementation of the code is developed. An ongoing work is concerned with the extension of this approach to reactive-transport equations.

F. Chalub – A cancer model was introduced and analyzed using different techniques by an interdisciplinary team including an hematologist, three physicists and a mathematician.

An other aspect concerns the rigorous derivation and analysis of a mathematical models similar to the Kimura equation.

P. J. Doutor – Some contributions for the generalization of the classical thermodynamic formalism for the class of almost additive sequences were carried out, establishing a conditional variational principle for the dimension spectra of Hölder continuous functions.

R. Martins – Criteria that guarantees the synchronization of coupled non-identical oscillators were obtained.

F. Oliveira – Existence of bound states for the Benney system with cubic nonlinearity and the local well-posedness of the 2D and 3D Zakharov-Schulman system below energy space are established. The trend to thermodynamical equilibrium for a new model concerning chemically active gases is also proved.

Ana M. Ribeiro – Existence for a nonlinear problem involving isotropic deformations is established.

M. L. Mascarenhas and Rita Ferreira – A new result concerning a mathematical approach to wave propagation in a periodic thin plate, was obtained.

Rita Ferreira also proceeded the study of relaxation of first order problems with linear growth, obtaining partial results in the scope of her Ph.D. thesis.

## Group Productivity

### Publications in peer review Journals

1. S. Antontsev, J. P. Dias, M. Figueira and F. Oliveira, Non-existence of global solutions for a quasilinear Benney system. *Journal of Mathematical Fluid Mechanics* (in print). IF: 0.94
2. L. Barreira and P. Doutor, Dimension spectra of hyperbolic flows, *Journal of Statistical Physics*, 136 (3), 505-525 (2009). IF: 1.621
3. L. Barreira and P. Doutor, Dimension spectra of almost additive sequences, *Nonlinearity*, 22 (11), 2761-2773 (2009). IF: 1.359
4. L. Barreira and P. Doutor, Almost additive multifractal analysis, *J. Math. Pures Appl.*, 92 (1), 1-17(2009). IF: 1.204
5. G. Bouchitté, I. Fonseca and L. Mascarenhas, The Cosserat Vector In Membrane Theory : A Variational Approach, *Journal of Convex Analysis*, 16 (2), 351-365 (2009). IF: 0.911
6. F.A.C.C. Chalub and M.O. Souza, From discrete to continuous evolution models: a unifying approach to drift-diffusion and replicator dynamics,

Theoretical Population Biology, 76(4) 268–277 (2009). IF: 1.578

7. F.A.C.C. Chalub and M.O. Souza, A non-standard evolution problem arising in population genetics, *Comm. Math. Sciences*, 7(2), 489–502 (2009). IF: 0.896

8. D. Dingli, F.A.C.C. Chalub, F.C. Santos, S. Van Segbroeck and J.M. Pacheco, Reply: Evolutionary game theory: lessons and limitations, a cancer perspective, *British Journal of Cancer*, 101, 2062–2063 (2009). IF: 4.846

9. D. Dingli, F.A.C.C. Chalub, F.C. Santos, S. Van Segbroeck and J.M. Pacheco, Disease phenotype as the outcome of an evolutionary game between cells, *British Journal of Cancer*, 101, 1124–1129 (2009). IF: 4.846

10. P. M. Girão and J. M. Gomes, Multibump nodal solutions for an indefinite superlinear elliptic problem, *J. Differ. Equations.*, 247 (4), 1001–1012 (2009). IF: 1.349

11. P. M. Girão and J. M. Gomes, Multi-bump nodal solutions for an indefinite non-homogeneous elliptic problem, *Proc. R. Soc. Edinb., Sect. A, Math.*, 139 (4), 797–817 (2009). IF: 0.770

12. J. M. Gomes, An energy-decreasing rearrangement of level sets preserving the domain and volume constraints, *Adv. Math.*, 222 (1), 130–150 (2009). ISI IF: 1.280

13. J. M. Gomes, Existence and estimates of some mountain-pass type solutions, *ESAIM, Control Optim. Calc. Var.*, 15 (3), 499–508 (2009). ISI IF: 0.787

14. M. Guerra, R. Pinto, R. Martins and J.P. Casquilho, On the effect of a rotating magnetic field or sample on the bend Freedericksz critical field in nematic slabs, *Molecular Crystals and Liquid Crystals*, 508, 337–347 (2009). IF: 0.537

15. J. Henry, B. Louro and M. C. Soares, Factorization by Invariant Embedding of a Boundary Value Problem for the Laplace Operator, *System modelling and Optimization*, IFIP Advances in Information and Communication Technology, 312, 282–292 (2009).

16. G. Kremer, F. Oliveira and A. J. Soares, H-theorem and trend to equilibrium of chemically reacting mixtures of gases, *Kinetic and Related Models*, 2, 333–343 (2009).

### **Other publications International**

1. F. Caetano, M. Gander, L. Halpern, and J. Szeftel, "Schwarz Waveform Relaxation Algorithms with Nonlinear Transmission Conditions for Reaction-Diffusion Equations", accepted for publication in the proceedings of the 19th International Conference on Domain Decomposition Methods.

2. F.A.C.C. Chalub, The Saros cycle: obtaining eclipse periodicity from Newton's laws, *Revista Brasileira de Ensino de Física*, 31(1) 1303 (2009).

### **Organization of conferences**

F.A.C.C. Chalub has been in the organizing board of two conferences:

1. Summer School and Workshop on Kinetic and Statistical Methods for Complex Particle Systems, Lisbon, Portugal – member of the organizing Committee

2. The Mathematics of Darwin's Legacy, Lisbon, Portugal – member of the Scientific Committee

### **Internationalization**

The team is involved in the ICTI Program in Applied Mathematics in collaboration with Carnegie Mellon Univ. (<http://icti.math.cmu.edu/>) and in the CoLab Program in Mathematics in collaboration with University of Austin at Texas (UTA) (<http://www.utaustinportugal.org/mathematics/>). In this framework, Fabio Chalub and Filipe Oliveira take part in three ongoing research projects, M. Luísa Mascarenhas gave a talk at CMU and Rita Ferreira is pursuing her PhD training.

In the framework of bilateral agreements on research collaboration between Portugal and Brazil, F. Chalub and F. Oliveira initiate two scientific projects in cooperation with Prof. M. Sousa from Universidade Federal Fluminense and Prof. F. Linares from IMPA.

The members of the team work in close cooperation with scientists from several foreign universities. M. Luísa Mascarenhas with Prof. Guy Bouchitté from Université de Toulon, Bento Louro prosecutes his work with Prof. J. Henry from INRIA Bordeaux Sud-Ouest, Filipe Oliveira collaborates with Prof. Gilberto Kremer from Universidade Federal do Paraná and is now starting a collaboration with Prof. J. Polewczak from California State University. Ana M. Ribeiro carries on her cooperation with Prof. G. Croce from Université du Havre and Prof. E. Zappale from Università di Salerno University while Filipa Caetano is still part of the research team of Prof. L. Halpern from Université Paris 13. Rogério Martins continues his collaboration with A. Ureña and R. Ortega from Universidad de Granada, Spain.

### **Future Research**

#### **Objectives**

General objectives

The main goal of our team has been the study of several issues in the area of Partial Differential Equations, Dynamical Systems and Numerical Analysis, as well as its applications to Continuum Mechanics and to Biology.

Specifics objectives

F. Caetano – The first aim is to develop optimized transmission conditions for a SWR algorithm for reactive-transport equations, and next to study kinetic finite volume schemes for the Euler system of gas dynamics equations.

F.A.C.C. Chalub – The objective is the application to different settings of the techniques used in the papers by Chalub and Souza to derive a generalization of the Kimura equation. Applications to epidemic models are already developed and other works in the same direction are in preparation.

P. J. Doutor – The research will be directed towards a generalization of the Thermodynamic Formalism in flows to the nonadditive case, and the obtention of a multifractal analysis for flows in some nonadditive cases.

B. Louro, M. Soares, M. d'Orey – The first objective is to establish the existence and uniqueness of solution for the Riccati equation in a more general domain. Application of the method to a steady generalized Stokes system is then considered. An other objective is to provide a mathematical method to derive exact transparent boundary conditions on a specific sub-region and propose numerical schemes to compute them.

R. Martins – The goal is to extend prior results obtained for the pendulum equation to the sine-Gordon equation, and to continue the study of some models formulated within the framework of the theory of liquid crystals in the presence of an alternating shear and magnetic fields.

F. Oliveira – Study of singularity formation and blow-up of solutions for the Zakharov-Schulman system.

Ana M. Ribeiro – She will initiate the study of some homogenization problems, in collaboration with G. Carita and E. Zappale, and the analysis of some variational problems related with differential inclusions in collaboration with A. C. Barroso and G. Croce.

She will also initiate a collaboration with other members of CMA, considering new problems on image processing.

M.L. Mascarenhas- Apart from proceeding her previous work in dimension reduction problems, she intends to study some non local effects in Membrane theory.

Rita Ferreira will proceed the study of relaxation of first and second order problems with linear growth. The aim is to develop mathematical tools related to the relaxation and multiple scale convergence in BV and BH spaces, to characterize the multiple-scale homogenized functional issuing from energies involving first and second order derivatives and with linear growth. This is the part of R. Ferreira PhD thesis, supervised by I.Fonseca and L. Mascarenhas, in the scope of the CMU-Portugal Program in Applied Mathematics.

### **Funding, source, dates**

Approved:

1. Research project ANR-07-CIS7-007-03, funded by Agence Nationale de la Recherche, France

Simulation Haute Performance du Stockage Géologique de CO<sub>2</sub>

Participating Investigator: F. Caetano

2. Project PTDC/MAT/66426/2006. Coordinator: F.A.C.C. Chalub

Total funding: 49.000 euros (2007-2010)

3. CMU-PT/0019/2007. Coordinator: F.A.C.C. Chalub

Total funding: 41.248 euros (2007-2011)

4. Bilateral Agreement Portugal-Brazil. Joint Coordinator: F.A.C.C. Chalub

Total funding: 10.000 euros (2009-2010)

5. UT Austin/MAT/0035/2008. Participating Investigators: F.A.C.C. Chalub, F. Oliveira

Total funding: 100.000 euros (2009–2013)

6. PTDC/FIS/70973/2006. Participating Investigators: F.A.C.C. Chalub

Total funding: 59.000 euros (2008-2011)

7. PTDC/MAT/68615/2006. Coordinator: Filipe Oliveira

Total funding: 20.000 euros (2007-2010)

8. Bilateral Agreement Portugal-Brazil.

Approved in 2009.

Joint coordinator: Filipe Oliveira

Total funding for the first year (2010): 5.000 euros

Submitted:

1. Acção integrada Luso-Espanhola-2010.

Acção Nº E98/10.

Coordinator: R. Martins

2. UTA\_CMU/MAT/0005/2009

Coordinator: M. L. Mascarenhas

Requested funding: 240.288,00 Euros

3. PTDC/MAT/109973/2009

Coordinator: M. L. Mascarenhas

Requested funding: 99.720,00 Euros

## Group Description

<b>Title of Research Group:</b>	(RG-LVT-297-1850) Operational Research
<b>Principal Investigator:</b>	Paula Alexandra da Costa Amaral Jorge
<b>Main Scientific Domain:</b>	Matemática
<b>Group Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

## Funding, source, dates

### Funding, source, dates

PTDC/MAT/64838/2006, FCT/MCTES

Computational Mathematical Finance

Principal Investigator: L. N. Vicente (CMUC)

Participating member: A.L. Custódio

Total funding: 69000€

(2007-2009)

## Objectives & Achievements

### Objectives

This group is organized in three main areas:

- combinatorial optimization (I. Correia, I. Gomes, S. Batista)
- nonlinear optimization (A. L. Custódio, C. Brás, M. Vieira, P. Amaral)
- and management science (I. Gomes).

More specifically our objectives are:

A. L. Custódio

- The convergence analysis of directional direct search methods typically assumes at least Lipschitz continuity of the objective function. Nevertheless, in practical applications, Lipschitz continuity can be a very strong assumption. It was our goal to investigate how much it could be possible to weaken this assumption, generalizing convergence results for directional direct search to non-Lipschitzian functions.

C. Brás

- The role of condition number is well established in a variety of numerical analysis problems and several techniques have been developed to estimate this value. Our goal is the development of a projected gradient algorithm for the condition number estimation based on the complementarity formulation of the problem.

I. Correia

- Development and comparison of models for hub location problems with capacity choices.
- Development of upper and lower bounds for a project scheduling problem with flexible resources.

I. Gomes

- The environmental impact of systems such as supply chains with reverse flows are a major concern in our modern society. Most of these systems are cost optimized but they lack environmental efficiency. Our goal is to assess their environmental impact and propose optimized structures in terms of cost and environmental efficiency.

- The recycling of packaging materials, imposed by the European Union (EU), has forced member states to develop new collection systems. The traditional routes defined for organic waste do not fit the particularities of packages: different vehicles, different collection rates, different bin locations. A multi-product, multi-depot periodic vehicle routing model is developed and applied to some problem instances based on the real problem under study.

- The Dial-a-Ride problem formulation is used to optimize the ambulance routing to take patients to treatment locations.

M. Vieira

- Understanding the meaning of the Farkas' unfeasibility certificate in the context of the SAT problem when we use Semidefinite Programming relaxations of the SAT problem.

P. Amaral

- Understanding how Copositive Programming could be applied to the correction of infeasible linear systems. Increase International collaboration

S. Batista

- Study of the stochastic generalized assignment problem.

### Main Achievements

#### General achievements:

During 2009, our group produced 13 publications: 7 papers in journal with peer-review, 3 papers in proceedings with peer-review, 1 paper in a national proceeding with peer-review, 1 national edited-book and 1 pre-print.

We participated in several national and international meeting where the developed research work was presented.

Five group members integrated the organizing committee of the 14th conference of the Portuguese Operational Research Society.

Our Operations Research Seminar continued on a regular basis. Some of the group members presented their ongoing work and some national researchers were invited to present their work in order to strengthen collaborations.

#### Specific achievements:

##### A. L. Custódio

- The research work initialized in 2008, concerning the incorporation of minimum Frobenius norm models in direct search, was finalized. A significant improvement of algorithmic performance was achieved by forming and minimizing least-squares regression models, when larger budgets of function evaluations are available. The results of this research motivated a new release (version 1.1) of the computational code SID-PSM.

- Using Rockafellar generalized directional derivatives (upper subderivatives), convergence results for directional direct search methods were generalized for non-Lipschitzian functions. Namely, we could state the nonnegativity of Rockafellar derivatives along the limit directions of subsequences of unsuccessful iterates when the function values converge to the function value at the limit point. This result was obtained assuming that the function is directionally Lipschitzian with respect to the limit direction. It was also possible, under appropriate conditions, to establish more insightful results by showing that the sequence of points generated by a directional direct search method eventually approaches the limit point along the locally best branch or step function (when the number of steps is equal to two).

##### I. Gomes

- The environmental impact of a Portuguese network for the waste of electric and electronic equipments was assessed and a network design and planning were optimized with respect to the developed metric.

- A MILP model for the design and planning of supply chains with reverse flows was developed and applied to a Portuguese producer and distributor of steel batteries.

- Submitted paper: M. I. Gomes, A. P. Barbosa-Povoa and A. Q. Novais. Modelling a recovery network for WEEE: a case study in Portugal, OMEGA

IF: 2.175

##### P. Amaral

- Development of Completely Positive (CpPP) and Copositive Programming (CoP) formulations for the Constrained Fractional Quadratic Problem (CFQP) and Standard Fractional Quadratic Problem (StFQP). Semidefinite Programming (SDP) formulations for finding good lower bounds to these fractional programs. Development of a global optimization branch-and-bound approach for the StFQP. Applications of the CFQP and StFQP in the correction of infeasible linear systems and eigenvalue complementarity problems.

##### S. Baptista

- In an emergency ambulance system, ambulances are assigned to demands based on assignment rules. In order to evaluate these rules, queueing and simulation models were applied to a Portuguese emergency system.

## Group Productivity

### Publications in peer review Journals

1. A. L. Custódio, H. Rocha and L. N. Vicente, Incorporating Minimum Frobenius Norm Models in Direct Search. Computational Optimization and Applications (accepted and available online). IF: 0.648

2. I. Correia, S. Nickel and F. Saldanha-da-Gama, Single-assignment hub location problems with multiple capacity levels. Transportation Research Part B: Methodological (accepted and available online). IF: 1.874

3. I. Correia, L. Gouveia, F. Saldanha da Gama, Discretized formulations for capacitated location problems with modular distribution costs. European Journal of Operational Research (accepted and available online). IF: 1.627

4. M. I. Salema, A. P. Barbosa-Povoa and A. Q. Novais. A strategic and tactical model for closed-loop supply chains. OR Spectrum, 31 (2009) (3), 573-599. IF:= 1.057

5. M. I. Salema, A. P. Barbosa-Povoa, A. Q. and Novais. Simultaneous design and planning of supply chains with reverse flows: A generic modelling framework. European Journal of Operational Research (accepted and available online). IF: 1.627

6. M. Vieira. Interior-point methods based on kernel functions for symmetric optimization. To appear in Optimization Methods and Software. IF: 0,708

7. P. Amaral, L. M. Fernandes, J. Júdice and H. Sherali. On optimal zero-preserving corrections for inconsistent linear systems, Journal of Global Optimization 45 (2009), 645-666. IF: 1.062.

### Other publications International

1. C. P. Brás, J. J. Júdice (2009). Complementary approaches for the computation of the independent number of a graph, Proceedings of the 14th WSEAS International Conference on Applied Mathematics (MATH'09), edited by C. A. Bulucea, V. Mladenov, E. Pop, M. Leba and N. Mastorakis, pp. 178-183.

2. I. Correia, L. Gouveia, F. Saldanha-da-Gama (2009). Discretized reformulations for a capacitated network loading problem arising in a facility location context, INOC 2009 Proceedings of the International Network Optimization Conference, Pisa, Itália, 26-29 Abril, 7 pages.

3. M. I. Gomes-Salema, A. P. Barbosa-Povoa, A. Q. Novais (2009). An eco-efficiency study for a WEEE recovery network: the Portuguese case. Proceedings of the 10th International Symposium on Process Systems Engineering, Salvador, Brazil, 16-20 August, 6 pages.

### **Other publications National**

Proceedings (peer-review)

- T. Ramos, M. I. Gomes-Salema, A. P. Barbosa-Povoa (2009). A multi-product, multi-depot vehicle routing problem in a reverse logistics system: comparative study of an exact formulation, Proceedings of the 14th conference of the Portuguese Operational Research Society, Caparica, Portugal, 7-9 September.

Edited-books (peer-review)

I. Gomes

- Livro de Actas da 14<sup>o</sup> congresso da Associação Portuguesa de Investigação Operacional co-editor A. P. Barbosa-Povoa (CEG-IST)

Pre-prints

- L. N. Vicente and A. L. Custódio, Analysis of direct searches for non-Lipschitzian functions, preprint 09-38, Dept. of Mathematics, Univ. Coimbra.

### **Master and Ph.D. thesis completed**

Training Masters (Master thesis completed)

I. Gomes

- Ana Fernandes (MEGI – IST): Optimization of a Batteries' Distribution Network with Reverse Flows, 17 de Novembro de 2009.

### **Organization of conferences**

C. Brás, I. Correia, I. Gomes, M. Vieira and P. Amaral (organizing committee) and I. Gomes (scientific committee)

- IO2009 - 14<sup>o</sup> Congresso da Associação Portuguesa de Investigação Operacional (14th meeting of the Portuguese Operational Research Society), held on Faculdade de Ciências e Tecnologia, of Universidade Nova de Lisboa, 7th to 9th of September, 2009.

C. Brás and P. Amaral (organizers)

Workshop on Global Optimization, by Eligius Hendrix of Málaga University, held on Faculdade de Ciências e Tecnologia, of Universidade Nova de Lisboa, 9th of September, 2009.

OR-CMA seminars (I. Gomes – organizer)

- Modelo de optimização para classificação de regiões de interesse em problemas de optimização linear inconsistentes, speaker Paula Amaral (CMA, FCT-UNL)

- Scheduling and the Resource-Task Network, speaker Pedro Castro (DMS, INETI)

- Meta-Heurísticas e Escalonamento em Tempo Contínuo, speaker Nelson Martins (CMA, FCT-UNL)

- Algoritmos evolucionários bi-objectivo para o problema de escalas de motoristas, speaker Ana Respício (CIO, FCUL)

### **Internationalization**

International collaboration:

I. Correia

- Stefan Nickel, Institute for Operations Research, University of Karlsruhe (TH), Karlsruhe, Germany Fraunhofer Institute for Industrial Mathematics (ITWM), Kaiserslautern, Germany (collaborative research)

- Maria Teresa Melo, Business School, Saarland University of Applied Sciences, Saarbrücken, Germany (collaborative research)

M. Vieira

- Miguel F. Anjos, University of Waterloo, Canada (collaborative research)

P. Amaral

- Hanif Sherali - GDI&SE, Virginia Polytechnic Institute & State University, USA (collaborative publication)

- Immanuel Bomze, - ISDS, University of Vienna, Austria (collaborative publication)

- Eligius Hendrix - Departamento de Arquitectura de Computadores, Universidad de Málaga, Spain (collaborative research)

- Leo Casado - Departamento de Arquitectura de Computadores y Electrónica, Universidad de Almería, Spain (collaborative research)

- Invitation by Inma Garcia coordinator of the group of Supercomputation and Algorithms of the University of Almeria to do collaborative research work for a period of 15 days and to present two seminars.

Invited talks:

AL. Custódio:

- A. L. Custódio, H. Rocha, and L. N. Vicente, Incorporating Minimum Frobenius Norm Models in Direct-Search, 20th International Symposium on Mathematical Programming, Chicago, USA, August 2009

## Future Research

### Objectives

General objectives:

The focus of our research has been on combinatorial and nonlinear optimization, and its applications to management science and engineering. We plan develop our research in the following sub-areas:

- Multiobjective optimization (A. L. Custódio)
- Complementarity (C. Brás)
- Facility location models (I. Correia and I. Gomes)
- Semidefinite programming (M. Vieira)

Specific objectives:

A. L. Custódio

- In real engineering applications, it is common to have several conflicting objective functions to optimize. Frequently, these functions are subject to noise or can be of blackbox type, preventing the use of derivative-based techniques. It is our goal to develop a new multiobjective derivative-free methodology which does not aggregate any of the objective functions.

C. Brás

- Sequential complementarity algorithms and parametric algorithms to solve linear and nonlinear problems with linear complementarity constraints.

I. Correia

- The current year will be dedicated to the study of two main problems: a multi-commodity two-echelon capacitated facility location problem with sizing decisions and a dynamic hub location problem.

I. Gomes

- My research will continue focus in the modelling of supply chains with reverse flows with respect to the assessment of their environmental impact. Another research objective concerns the modeling of collection systems for recycled end-of-life products. A model is being developed that simultaneously considers the definition of vehicles routes and services areas.

M. Vieira

- Understanding the meaning of the Farkas' unfeasibility certificate in the context of the SAT problem when we use Semidefinite Programming relaxations of the SAT problem.

P. Amaral

- Continue research on Copositive Programming and applications.
- Visit Immanuel Bomze for a period of ten days to do research.

S. Baptista

- Study of the stochastic generalized assignment problem

### Funding, source, dates

PTDC/MAT/098214/2008, FCT/MCTES

Derivative-Free Optimization: Future Challenges and New Applications

Principal Investigator: L. N. Vicente, University of Coimbra,

Other core members: A. L. Custódio, New University of Lisbon, A. I. F. Vaz, University of Minho,

Total funding: 158256 euros

(2010-2012)

PTDC/SEN-ENR/102869/2008, FCT/MCTES

PEERChain – Design and Planning of Energy Efficient and Resilient Supply Chains.

Principal Investigator: Ana Póvoa

Participating member: Isabel Gomes and Nelson Martins

Total founding 199.992 euros

Duration: 36 months. Starting date: Janeiro de 2010.

## Group Description

<b>Title of Research Group:</b>	(RG-LVT-297-1852) Actuarial and Financial Mathematics
<b>Principal Investigator:</b>	Manuel Leote Tavares Ingles Esquivel
<b>Main Scientific Domain:</b>	Matemática
<b>Group Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

## Funding, source, dates

### Funding, source, dates

PTDC/ECO/64968/2006, FCT/MCTES

Beliefs, speculation and temporary equilibrium

Principal Investigator: Mário Páscoa (FE/UNL)

Participating member: M. Faias.

Total Funding: 118 000,00 euros

(2007-2009)

Acção Nº E-113/08, CRUP - Acções Integradas Luso-Espanholas,

Information and Markets

Principal Investigator: Cesaltina Pires.

Participating member: M. Faias.

Total Funding: 1 500,00

(2008-2009)

SA0870A08, Junta de Castilla y León.

Mercados, Coaliciones e Información

Principal Investigator: Emma Moreno.

Participating member: M. Faias.

Total Funding: 2 000,00

(2008-2010)

## Objectives & Achievements

### Objectives

Carlos Veiga

To conclude a running research project focused on unifying exotic options pricing, thus enabling the combination of diverse features from different types in one claim. It also contributes to design of generic pricing tools and efficient valuation. Develop a research project aimed at finding more suitable financial contracts than the existing ones to improve hedging performance, enable trading strategies that generate profits/losses linked to relevant statistics of the returns distributions.

Gonçalo dos Reis

The aimed research goals for 2009 were: To do research on numerical methods for quadratic BSDEs and to finish a work concerning securitization and equilibrium pricing of weather risks.

João Beleza Sousa

Extend the developed calibration procedure to other non-Gaussian mathematical finance models. Apply machine learning kernel methods to the calibration of mathematical finance models.

Miguel Brás de Carvalho

The two main objectives were to complete thesis and to deposit research resources on the topic of Statistics of Extremes.

Marta Faias

In the context of the differential information economies, our aim was to derive and discuss the existence of Walrasian equilibrium as equilibrium of a noncooperative Nash game following the Shapley-Shubik (1977) game theoretic approach.

In the context of economies with a nonatomic continuum of traders and a continuum of differentiated commodities our plan was to use coalitional game theory to explore the Shapley value (Shapley, 1953) to address the questions relative to the market power of agents.

Maria de Lurdes Afonso

To submit the paper "Numerical evaluation of continuous time ruin probabilities for a portfolio with credibility updated premiums". To work on the project mentioned above. To apply the methodology developed on the PhD Thesis to a Bonus Mallus System.

Manuel Esquivel

In Financial Mathematics: to finish the study of SDE models on futures commodities and on price/liquidity, mainly benchmarking the models with real data against traditional models; to expand the study of a method for premium computation. On random algorithms: to improve the convergence results obtained for adaptive random search. On asymptotic random expansions: to explore further the technique introduced allowing to transfer information from an asymptotic relation in probability to a distribution approximation. The cooperation with BIG will deal with credit risk and V@R.

Pedro Mota

Continue with the study of continuous time threshold models. Generalize the continuous time threshold models and prove asymptotic results for the parameter estimators. Submit papers for publication regarding the past and present research.

Rui Cardoso

To continue the work about dividends considering the possibility of a dynamic criteria for dividend payments; to study optimal dynamic reinsurance, in collaboration with Professors D. Dickson, H. Waters and L. Afonso; to extend some of the results known in the classical risk model to the dual risk model concerning the payment of dividends. This is a joint work with Professors H. Waters, A. Egídio dos Reis and L. Afonso.

Rute Carrujo

To finish the master's degree in "Mathematics and Applications" featuring the master's thesis under the title "Long Term Care Insurance: Proposal of a financial-actuarial evaluation model". To start the PhD degree in order to further study of Long Term Care Insurance.

### **Main Achievements**

Carlos Veiga

Successful conclusion of the research project that covers the analysis and comparison of structured products. This is due to be published early 2010.

João Beleza Sousa

The calibration of the Vasicek interest rate model with Gaussian processes for machine learning was concluded.

Gonçalo dos Reis

The basis for algorithms for BSDE with drivers that grow quadratically in the control variable was laid down in [IdR2010]. The authors provide an explicit convergence rate for truncations of BSDE with such drivers as well as results on the path regularity of the solution processes for such equations.

The work on securitization and pricing of derivatives based on non-tradable risk was successfully concluded (see [HPdR2010]).

Miguel Brás de Carvalho

The main achievement deserving reference is the establishment of partnerships towards joint work on Statistics of Extremes with members from CEUL (viz.: K. Feridun Turkman and M. Antónia Turkman) - Universidade de Lisboa, and from Centre Interfacultaire Bernoulli (namely: Anthony Davison and Mathieu Ribatet) from Ecole Polytechnique Fédérale de Lausanne.

Marta Faias

In the first work, the Shapley-Shubik approach to differential information economies, we already obtain existence of equilibrium, we are working in characterizations of the equilibrium and we expect to submit the paper shortly.

In the second work we defined the Shapley value concept in economies with a nonatomic continuum of traders and a continuum of differentiated commodities. We proved that the value is well defined and we already prove that a value allocation is a competitive allocation. We are now searching the assumptions which guarantee that a competitive allocation is a value allocation. The final aim is to characterize the market power of agents.

Maria de Lurdes Afonso

We have submitted the paper "Numerical evaluation of continuous time ruin probabilities for a portfolio with credibility updated premiums" to ASTIN Bulletin.

Manuel Esquivel

With the exception of the objectives dealing with stochastic algorithms all the objectives were attained.

Rui Cardoso

I start a review of the literature concerning: the work about optimal dynamic reinsurance; the work in the dual risk model with payment of dividends. Some minor results were obtained for the work about the dual risk model.

Rute Carrujo

Finished master's degree in "Mathematics and Applications" with the presentation of the dissertation about Long Term Care Insurance. Started the PhD studies enrolling in the PhD Program Statistics and Risk Management at FCT/UNL.

Other important achievements

Miguel Brás de Carvalho

Award of Portuguese Statistical Society, 2009 (jointly with Paulo C. Rodrigues).

Miguel Brás de Carvalho

Elected National representative at the 16th-European Young Statisticians Meeting, organized under the auspices of the European Regional Committee of the Bernoulli Society.

Marta Faias

Invited Speaker at the "III Workshop on Economic Theory, Frontiers in Economic Theory and Applications", Vigo Spain, September.

Manuel Esquivel

Scientific 'Copy Editor' for LEYA editing house.

Manuel Esquivel

Scientific Consulting to a private bank with foreign capital for implementation of statistical methodologies and Value-at-Risk.

Marta Faias

Regular participation in the ClubeMath activities: (<http://clubemath.dmat.fct.unl.pt/>).

Maria de Lurdes Afonso

Participation in a ClubeMath activity: June 6, End of Academic Year Special Peddy Paper (<http://clubemath.dmat.fct.unl.pt/>).

Maria de Lurdes Afonso

Participation in a EXPO FCT activity: April 4th. (<http://www.fct.unl.pt/expofct/>).

## Submitted papers

1. J. Beleza Sousa & M. L. Esquível & R. M. Gaspar. Machine learning Vasicek model calibration with Gaussian processes. Preprint. Submitted to Elsevier Journal of Statistical Planning and Inference.
2. M. de Carvalho & K.F. Turkman & A. Rua. Nonstationary Extremes and the US Business Cycle. Working Paper of Banco de Portugal. To appear.
3. P. P. Mota & M. L. Esquível. On a Continuous Time Stock Proce Model with Regime Switching, Delay and Threshold. Preprint. Submitted to Quantitative Finance.
4. R. Cardoso. Dividends and ruin problems in finite time – Second version. Preprint. Submitted to ASTIN Bulletin.
5. C. Veiga & U. Wystup & M. L. Esquível. Unifying Exotic Option Closed Formulas. Frankfurt School Working Paper, CPQF No. 23. Submitted to Review of Derivatives Research.

## Group Productivity

### Publications in peer review Journals

1. C. Veiga & U. Wystup. Closed Formula for Options with Discrete Dividends and its Derivatives. Applied Mathematical Finance, Volume 16 (2009), Issue 6, 517-531.
2. S. Ankirchner & P. Imkeller & G. Dos Reis. Pricing and hedging of derivatives based on non-tradable underlyings. Mathematical Finance. To appear. IF: 1.237
3. P. Imkeller & G. Dos Reis. Path regularity and explicit convergence rate for BSDE with truncated quadratic growth. Stochastic Processes and their Applications, Issue 3, Volume 120, Issue 3, 348-379, To appear. IF:1.068
4. U. Horst & T. Pirvu & G. Dos Reis. On Securitization, Market Completion and Equilibrium Risk Transfer. Mathematics and Financial Economics. To appear (DOI: 10.1007/s11579-010-0022-1).
5. M. Farias & Emma Moreno. Incomplete Financial Markets and Differential Information. Economic Theory. (2009) 2. To appear. (DOI: 10.1007/s00199-008-0429-6).
6. Lourdes B. Afonso & Alfredo D. Egidio dos Reis & Howard R. Waters. Calculating continuous time ruin probabilities for a large portfolio with varying premiums. ASTIN Bulletin. Volume 39 (2009) 1, 117-136. IF: 0.902
7. M. L. Esquível. Some applications of probability generating function based methods to statistical estimation. Discuss. Math., Probab. Stat. 29, No. 2 . To appear.

### Other publications International

1. C. Veiga & U. Wystup. Issuers' commitments would add more value than any rating scheme could ever do. In: Contemporary Quantitative Finance (Essays in Honour of Eckhard Platen). Chiarella, C. and Novikov, A. (Eds.) To appear. New York, Springer, Springer, ISBN: 978-3-642-03478-7.
2. P. Imkeller & G. Dos Reis & J. Zhang. Results on numerics for FBSDE with drivers of quadratic growth. Contemporary Quantitative Finance (Essays in Honour of Eckhard Platen). To appear. New York, Springer, ISBN: 978-3-642-03478-7.
3. J. Beleza Sousa. Machine Learning Vasicek Model Calibration with Gaussian Processes. Proceedings of the 6th St. Petersburg Workshop on Simulation I, 425-429 (2009).
4. M. de Carvalho. Recasting Mean Regression for Censored Survival Times. Proceedings of the 16th European Young Statisticians Meeting – European Regional Committee of the Bernoulli Society (2009).
5. M. de Carvalho & M. L. Esquível & J. T. Mexia. A General Stochastic Optimization Method for Extremum Estimators. Proceedings of the 6th St. Petersburg Workshop on Simulation I, 431-435 (2009).
6. N. S. Rianço & M. L. Esquível & P.P. Mota & C. Veiga. On a Price-Liquidity Threshold Regime Switcing Model (preliminary report). Proceedings of the 6th St. Petersburg Workshop on Simulation I, 419-424 (2009).
7. I. B. Cabrera & M. L. Esquível. Spot/Futures Coupled Model for Commodity Pricing. Proceedings of the 6th St. Petersburg Workshop on Simulation I, 437-441 (2009).
8. M. L. Esquível & J. T. Mexia & J. L. da Silva & L. P. C. Ramos. Some Asymptotic Expansions and Distribution Approximations outside a CLT Context. Proceedings of the 6th St. Petersburg Workshop on Simulation I, 444-448 (2009).

### Other publications National

C. Veiga & U. Wystup & M. L. Esquível. Unifying Exotic Option Closed Formulas. Frankfurt School Working Paper, CPQF No. 23. Submitted to Review of Derivatives Research.

[http://www.frankfurt-school.de/content/en/research/cpqf/publications/research\\_publications](http://www.frankfurt-school.de/content/en/research/cpqf/publications/research_publications)

### Master and Ph.D. thesis completed

Master thesis completed

Orientador: Rui Cardoso

Susete Tomás Santos, student of the Master in Mathematics and Applications FCT (Actuarial Mathematics) with the thesis "Rate-making of motor third party liability insurance".

Orientador: Rui Cardoso

Tânia Sofia Marques Novo, student of the Master in Mathematics and Applications FCT (Actuarial Mathematics) with the thesis "Underwriting risk analysis under the Solvency II project".

Orientador: Rui Cardoso

Ana Isabel Martins, student of the Master in Mathematics and Applications FCT (Actuarial Mathematics) with the thesis "Impact of the changes on the Social Security Laws in Pension Funds' solvency".

Orientador: Manuel Esquivel

Rute Baião Carrujo, student of the Master in Mathematics and Applications FCT (Actuarial Mathematics) with the thesis "Long Term Care Insurance: Proposal of a financial-actuarial evaluation model".

PhD thesis completed

Orientadores: João Tiago Mexia and Manuel L. Esquivel

Miguel Brás de Carvalho, "Extremum Estimators and Stochastic Optimization Methods" at the FCT/UNL, approved by unanimity.

## Organization of conferences

Marta Faias

"10th Annual Conference - The Association for Public Economic Theory", National University of Ireland, Galway, Ireland, June. Program Committee. Organizer of a Session. Talk presentation.

Manuel Esquivel

"XVII National Congress Of the Portuguese Statistical Society", Sesimbra (Portugal), September 30 to October 3, 2009, member of the Organizing Committee.

Manuel Esquivel

"First Workshop Financial Mathematics – Models and Statistical Methods", Sesimbra (Portugal), September 29, 2009, Organizer.

## Internationalization

João Beleza Sousa: talk given at Financial Mathematics, Models and Statistical Methods Workshop: Machine learning vasicek model calibration. Sesimbra, September 29, 2009.

Miguel de Carvalho, Paulo C. Rodrigues and Nuno Sepulveda (Instituto Gulbenkian Ciência) have established connections with the European Regional Committee of the Bernoulli Society. As a consequence of these efforts the 17th-European Young Statisticians Meeting will be organized by them in Portugal, during 2011.

Miguel de Carvalho: talk given at an International Course on Bayesian Statistics: "Bayesian Methods and Extreme Value Statistics: A Marriage of Convenience," ABS09, Applied Bayesian Statistics School 2009, Accademia Cusano – Bressanone, Italy, June 15-18.

Miguel de Carvalho: visiting Position at the Institute of Mathematics, Ecole Polytechnique Fédérale de Lausanne.

Marta Faias: invited participant at the "Sorbonne Workshop in Economic Theory", Paris, France, June 2009.

Marta Faias: talk given at the "3rd Meeting of the Portuguese Economic Journal", Funchal, Portugal, June 2009.

Marta Faias: talk given at the "9th SAET Conference on Current Trends in Economics", Ischia, Italy, June-July 2009.

Marta Faias: visit to the Economics Faculty of the University of Salamanca to work with Professor Emma Moreno, May, 11 to 13.

Marta Faias: visit to the the University of Arizona in Tucson (USA) to work with Professor Myrna Wooders, November, 21 to 28.

Manuel Esquivel: invited organizer of a special session "Stochastic Simulation and Algorithmic Methods for Applied Mathematical Finance" in the 6th St. Petersburg Workshop on Simulation, St. Petersburg (Russia), June 28-July 4.

Rui Cardoso e Manuel Esquivel: Professor Howard R. Waters, of Heriot Watt University, Edinburgh (UK) visited the CMA in June.

## Future Research

### Objectives

Gonçalo Reis

Do research on systemic risk. Continue research on BSDE, in particular numerical methods. Diversify the research focus, namely follow the direction of control theory.

Miguel Brás de Carvalho

Mainly two objectives: to continue allocating research resources on the topic of Statistics of Extremes and post-doctoral studies.

Marta Faias

To continue the work in differential information economies with the aim of characterize the equilibrium results already proved. To continue the work in economies with an infinite continuum set of agent and also an infinite continuum set of agents, precisely, searching the assumptions which guarantee that a competitive allocation is a value allocation. The final issue will be to characterize the market power of agents. To explore existence and characterization results in economies with public goods. In this topic we will undertake a new approach, namely, we consider a strategic approach through the use of a proper Shapley-Shubik game. Submit for publications papers in these subjects.

Maria de Lurdes Afonso

To continue the work about applying the methodology developed on the PhD Thesis to a Bonus Mallus System with Alfredo Egidio dos Reis and Howard Waters. To study optimal dynamic reinsurance, in collaboration with Professors David Dickson, Howard. Waters and Rui Cardoso; To extend some of the results known in the classical risk model to the dual risk model concerning the payment of dividends. This is a joint work with Professors Howard Waters, Alfredo Egidio dos Reis and Rui Cardoso.

Manuel Esquivel

With Pedro Mota to study regime switching pricing models. With João Beleza Sousa to study Machine Learning methods for calibration of stochastic process financial models. With Gracinda Guerreiro, Rute Carrujo e Catarina Vale to study applications of Markov modes to finance and industry. With

João Lita da Silva, Luís Ramos e João Tiago Mexia to further develop the asymptotic results based on Esseen type estimates.

Rui Cardoso

To continue with the work started in 2009 concerning the dual risk model with payment of dividends and the optimal dynamic reinsurance.

Rute Carrujo

Markovian Modeling of Open Populations subject to Reclassifications: Application in the Long Term Care Insurance; Markovian Modeling of Open Populations subject to Reclassifications in the continuous time case.

#### **Funding, source, dates**

Pending funding

DEE/2009/002330

Visiting researcher fellowship at the Banco de Portugal.

Miguel Brás de Carvalho

Title of work plan: "Extreme Value Econometrics".

Total funding: 2292 euros/ month Reference: DEE/2009/002330.

November 2009 - May 2010

Project submitted to FCT/MCTES (2009)

Economies with differential information and differentiated goods

Principal Investigator: João Correia da Silva

Participating member: Marta Faias

Total Funding: 33264,00 euros

Funding by Banco Privado Atlântico Europa:

Risk Management Development Tool

Principal Investigator: Manuel L. Esquível

Participating member: João Beleza Sousa

Total Funding: 31000 euros

March-June 2010

PTDC/EGE-ECO/108481/2008, FCT/MCTES

Evaluation of dividend barrier variables in the actuarial dual risk model project number

Principal researcher: Alfredo Egídio dos Reis

Participating members: Rui Cardoso and Maria de Lurdes Afonso

Total Funding: 21510 euros

Starting date: 1/2/2010 duration: 36 months,