



## PROGETTO

“Modelli e Tecniche di Ottimizzazione Stocastica  
per Sistemi di Supporto decisionale”

*Responsabile scientifico: Prof. Giorgio Consigli*

2007-2008-2009



**RELAZIONE TECNICO SCIENTIFICA CONCLUSIVA**

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## I. SINTESI DEL PROGETTO

Il progetto *Modelli e Tecniche di Ottimizzazione Stocastica* (a seguire il progetto *Cariplo* o semplicemente il *progetto*) ha rappresentato un'esperienza dagli elevati contenuti qualitativi e di grande impatto sulla struttura organizzante con rilevanti ricadute formative ed apertura al contesto internazionale.

Il progetto si inquadra nell'ambito dell'attività di formazione post-universitaria di eccellenza con una chiara finalità: il potenziamento attraverso un network di istituzioni accademiche operanti in diversi paesi europei dell'offerta formativa post-universitaria in un'area scientifica e tecnica con notevoli ricadute applicative e dal marcato carattere interdisciplinare. L'attività formativa era orientata alla teoria dell'ottimizzazione, in particolare applicata alla soluzione di problemi decisionali caratterizzati da grandezze aleatorie, propriamente denominata *programmazione stocastica* (PS).

Il progetto si è strutturato in attività formativa a livello post-universitario ed in particolare di dottorato ed in tre eventi, due scuole ed un workshop realizzati tra il 1 gennaio 2007 ed il 31 dicembre 2009.

Sono state interessate al progetto oltre all'università di Bergamo -- in particolare nel Dipartimento di Matematica, Statistica, Informatica ed Applicazioni (DMSIA) dell'Ateneo, centro di coordinamento ed unità proponente del progetto --, quattro realtà accademiche ciascuna con competenze e specificità proprie di riconosciuto valore internazionale: il Dipartimento di Statistica e sistemi decisionali dell'università di Vienna, i Dipartimenti di Matematica dell'università di Edimburgo e di Matematica applicata dell'università di West-London Brunel, il Dipartimento di Economia industriale e tecnologie dell'università di Trondheim in Norvegia.

Il progetto è stato coordinato dai responsabili delle singole unità di ricerca:

- Professor Georg Pflug per il Department of Statistics and Decision Support Systems (DSDSS) dell'Università di Vienna (AU) ([www.univie.at](http://www.univie.at))
- Professor Gautam Mitra direttore del Center of applied research CARISMA presso l'Università di West London Brunel (GB) ([www.carisma.ac.uk](http://www.carisma.ac.uk))
- Il Professor Jacek Gondzio della School of Mathematics dell'Università di Edinborough (SMED) in Scozia (GB) ([www.maths.ed.ac.uk](http://www.maths.ed.ac.uk))
- Il Professor Alexei Gaivoronski del Department of Industrial Economics and Technology management della Norwegian University of Technology (NTNU) di Trondheim in Norvegia ([http://www.iot.ntnu.no/english/\\_main.asp](http://www.iot.ntnu.no/english/_main.asp))
- Il coordinatore e relatore della presente relazione, Prof. Giorgio Consigli dell'Università degli Studi di Bergamo.

Tre, come detto, le iniziative formative specifiche, dedicate all'ottimizzazione stocastica:

- (1) La prima scuola di *Stochastic Programming: Theory and Applications* organizzata a Bergamo dal 10 al 20 aprile 2007.
- (2) Il *CARIPLO Workshop on Numerical Linear and Nonlinear Stochastic Programming*, Sep 3, 2008 - Sep 5, 2008 organizzato dall'università di Edimburgo
- (3) La seconda scuola di *Stochastic Programming: Theory and Applications* organizzata a Bergamo dal 23 al 28 novembre 2009.

Ad esse dobbiamo aggiungere gli scambi legati all'offerta di percorsi formativi sui temi dell'ottimizzazione stocastica nell'ambito del Dottorato di Metodi computazionali e previsioni economico-finanziarie dell'Università di Bergamo.

A conclusione del progetto, possiamo affermare che nel triennio, in relazione alle tematiche affrontate, avanzate da un punto di vista formativo e dal carattere fortemente multidisciplinare, l'Università di Bergamo ha rappresentato il principale centro accademico di confronto e di scambio a livello internazionale e focalizzato un interesse ed attenzione crescenti nella comunità accademica italiana ed estera. Il progetto ha mantenuto le sue promesse ed ha consentito ad un gran numero di studenti di interagire ed avviare forme di collaborazione e scambio. Gli studenti sono stati al centro della programmazione delle attività proposte dalle unità accademiche interessate in ogni fase del progetto.

## **II. ATTIVITA' FORMATIVA ED INTERNAZIONALIZZAZIONE**

La collaborazione tra le cinque UR del network si è concretizzata con le seguenti modalità:

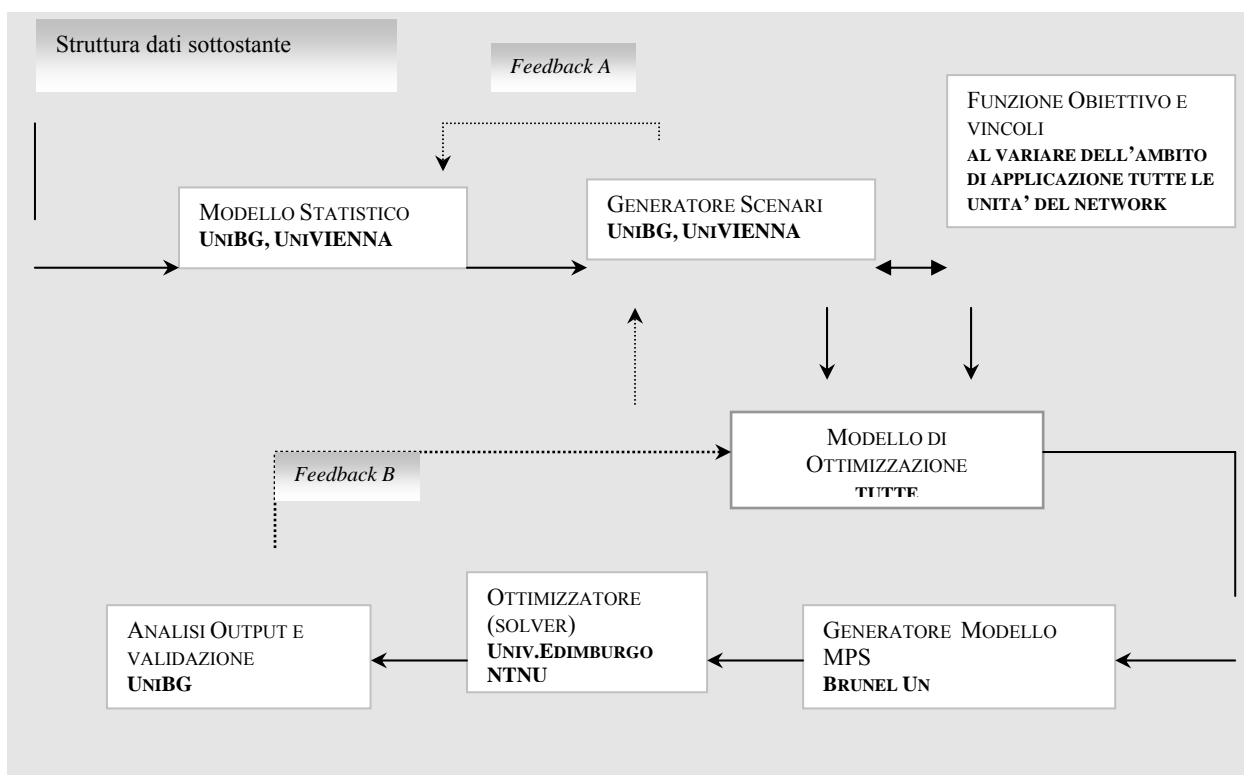
- ❑ Scambio di studenti con finalità formative
- ❑ Organizzazione di specifiche iniziative didattiche e di confronto tra le università aderenti al network

In particolare assegnisti italiani nell'arco dei 3 anni hanno seguito corsi post-graduate presso le citate università e viceversa, i docenti e studenti stranieri ed italiani hanno tenuto e frequentato corsi di dottorato tenuti presso la nostra università. Le scuole del 2007 e 2009 ed il workshop del 2008 hanno rappresentato importanti momenti di incontro ed approfondimento per una molteplicità di studenti delle più diverse provenienze: tutti legati dall'interesse per i metodi di ottimizzazione applicati in ambito economico-finanziario ed industriale.

L'attività di formazione si è posta ad un livello avanzato di dottorato e post universitario. La scuola organizzata per l'aprile del 2007 ha coinvolto in uno sforzo organizzativo rilevante un insieme esteso di docenti provenienti da altre Università (oltre alle università del Network Cariplo) coprendo una

molteplicità di aree applicative ed introducendo ai temi dell'ottimizzazione stocastica un gruppo molto ampio di studenti. Le finalità dell'evento e la sua organizzazione sono descritte in dettaglio nell'appendice A. La scuola del 2007 è stata realizzata prima dell'avvenuta comunicazione di sostegno finanziario della Fondazione per il triennio e per tale motivo al momento dell'evento non erano state predisposte forme di particolare pubblicità dell'Ente. Esso è stato peraltro inserito nel sito ex-post e richiamato nelle pubblicazioni associate alla school. Sin da principio, invece, i due eventi organizzati nel 2008 presso l'università di Edimburgo e nel 2009 ancora presso l'università di Bergamo hanno beneficiato della Grant e dei cofinanziamenti concessi e sin dall'inizio vi è stata una continua interazione con la Fondazione Cariplo ed il successo delle due iniziative è in buona parte legato alle borse di studio finanziate dalla Fondazione.

Il seguente workflow aiuta a comprendere i contributi delle diverse unità del network, il loro grado di complementarità e l'adottata offerta formativa in diretta relazione con la struttura generalmente implementata a livello applicativo.



**Grafico 1. Schema orientativo su tematiche e competenze unità accademiche network Cariplo**

L'ottimizzazione stocastica coniuga infatti ad un livello multidisciplinare avanzato elementi di matematica, statistica e teoria dei processi stocastici, analisi numerica e programmazione matematica. Il suo forte orientamento applicativo si è negli anni venuto consolidando accompagnato da contributi

teorici specifici nell'ambito di un insieme di aree qui brevemente richiamate e le quali hanno appunto visto il contributo importante delle unità del network:

- a) teoria dell'approssimazione e spazi funzionali (Pflug et al)
- b) teoria delle decisioni in condizioni di incertezza ed avversione al rischio (Pflug, Consigli, Mitra)
- c) linguaggi algebrici (Mitra et al)
- d) ottimizzazione lineare e nonlineare (Mitra et al, Consigli et al)
- e) algoritmi risolutivi (Gondzio et al, Gaivoronski et al)

Nelle successive sezioni sintetizziamo brevemente gli eventi ed offriamo una fotografia delle sinergie sviluppatasi tra le unità accademiche afferenti alla rete di collaborazione, gli studenti e tra l'università di Bergamo in particolare ed alcune imprese e realtà aziendali ed associative interessate all'iniziativa.

## **II. A LE SCUOLE DEL 2007 E 2009 ED IL WORKSHOP DEL 2008**

Il triennio di attività ha sottoposto l'ente proponente ad un significativo sforzo organizzativo e di coordinamento, iniziato con la school del 2007 concepita come detto prima dell'avvenuta comunicazione dell'importante contributo da parte della Fondazione CARIPLO.

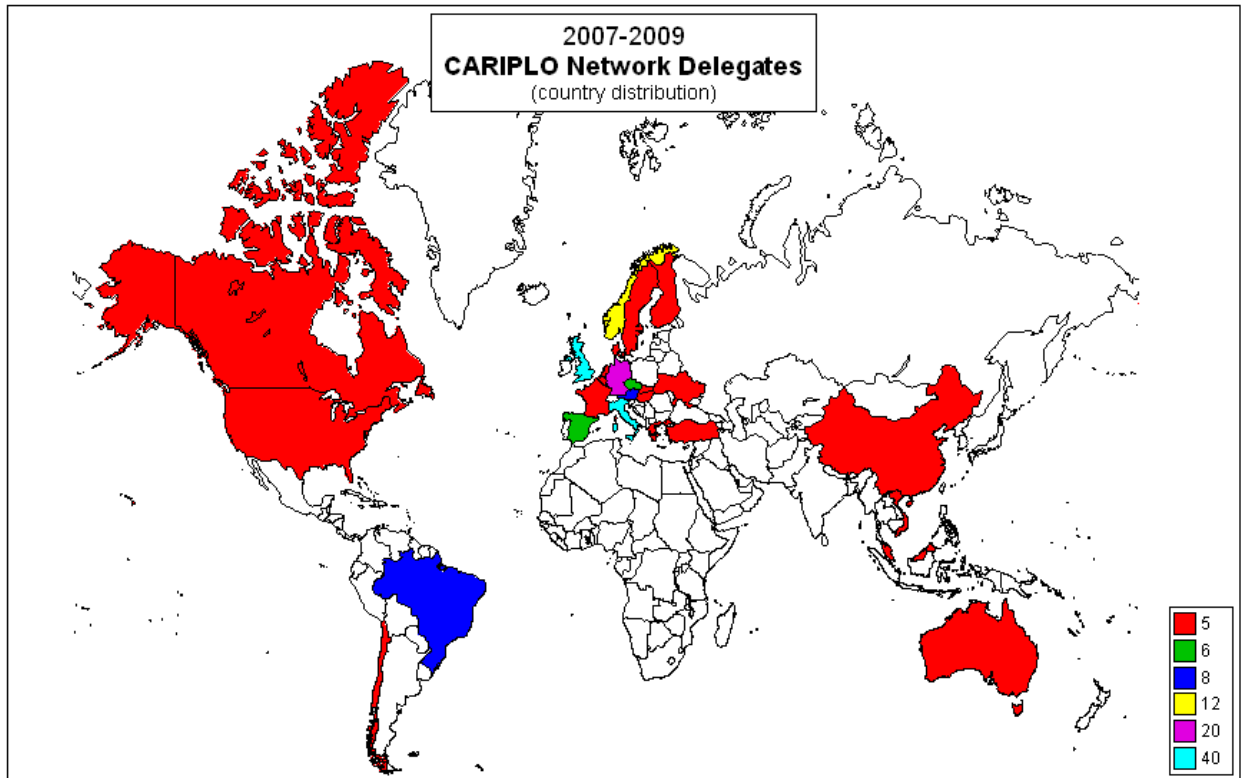
I tre eventi su richiamati hanno presentato tre modelli organizzativi diversi concretizzatisi in una scuola a tempo pieno distribuita su due settimane nel 2007, un workshop di 3 giorni nel 2008 ed infine una scuola di 6 giorni nell'autunno del 2009.

Il primo evento ha raccolto presso l'università di Bergamo un gran numero di docenti distribuiti su una proposta formativa predefinita in base alle rispettive competenze ed ha avuto una forte connotazione applicativa come evidenziato in appendice A. Lezioni di natura teorica ed introduttive si tenevano al mattino mentre tra fine mattinata e pomeriggio veniva lasciato spazio all'analisi delle applicazioni in una molteplicità di contesti operativi: in particolare per i settori della finanza, dell'energia, della logistica e trasporti, telecomunicazioni, produzione industriale, biomedico e delle scienze biologiche alternando contributi accademici ed offerti da rappresentanti del mondo dell'impresa. L'iniziativa ha beneficiato oltre che dell'importante sostegno della Fondazione, delle sponsorizzazioni della ProUniversitate Bergomensis diretta emanazione della realtà confindustriale della provincia di Bergamo, della società di gestione del risparmio Pioneer Investments del gruppo UniCredito, società globale e leader a livello europeo, dell'associazione italiana della matematica applicata Amases.

La scuola del 2007 ha rappresentato la prima iniziativa di questo tipo in ambito internazionale e si è proposta in ideale introduzione al simposio di ottimizzazione che viene tenuto ogni tre anni e nell'agosto del 2007 ha avuto luogo presso l'università di Vienna, uno dei partners del network Cariplo. Parimenti la scuola del 2009 anticipa il simposio che si terrà nell'anno corrente in Canada (si veda quanto riportato nell'appendice C).

La school del 2009 ha visto una proposta formativa da parte di docenti delle 5 università del network, senza ricorso a docenti di altre realtà universitarie ed ha peraltro mantenuto una forte vocazione applicata, alternando lezioni teoriche a lezioni mirate su applicazioni per i settori in particolare finanziario ed energetico. Nel modulo del 2009 è stato proposto per la prima volta un percorso basato su sezioni al computer nelle quali le diverse università del network hanno interagito per offrire agli studenti un'importante introduzione agli aspetti di programmazione e numerici legati alle applicazioni di ottimizzazione stocastica.

Nei tre anni un totale di 174 studenti provenienti da 27 paesi ha beneficiato dell'offerta formativa ed una ampia parte degli stessi ha usufruito delle scholarships finanziate dalla Fondazione CARIPLO: in totale i borsisti sono stati 98 (sps2007:30, wkshop2008:25, sps2009:43).

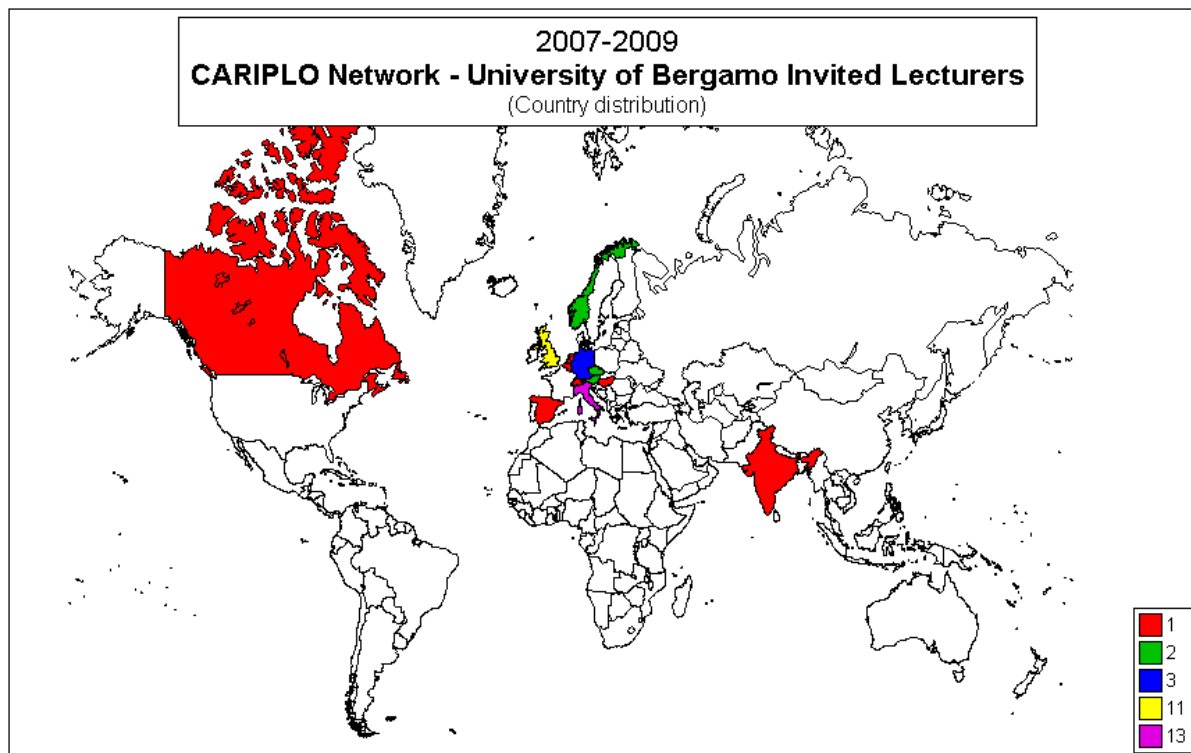


**Grafico 2. Mappa partecipanti ai tre eventi del progetto CARIPLO formazione avanzata ottimizzazione stocastica**

La distribuzione geografica degli studenti e la qualità delle sedi accademiche di provenienza valorizzano enormemente l'esperienza realizzata. La struttura degli eventi realizzati si è dimostrata particolarmente proficua avendo coniugato un percorso intensivo con la possibilità concessa ad un sottoinsieme di partecipanti di presentare le proprie ricerche in presenza di accademici di sicuro standard internazionale. I tre eventi da un punto di vista scientifico hanno tutti cercato di coniugare aspetti teorici ed applicati e per questi ultimi i singoli passaggi tipici nella formulazione e soluzione di problemi di ottimizzazione stocastica.

Aldilà dei corsi di dottorato tutti afferenti al dottorato di *Metodi computazionali per le previsioni economiche e finanziarie* offerto dall'università di Bergamo di cui diremo nella sezione successiva, le tre iniziative citate hanno coinvolto un significativo numero di docenti italiani ed esteri ed in particolare nel 2007, le sinergie didattiche sono risultate significative. Nei tre anni abbiamo ospitato 43 docenti provenienti da 14 paesi principalmente europei ma anche extra-europei come mostrato nella seguente mappa.





**Grafico 3. Mappa provenienza corpo docente eventi progetto CARIPLO**

Con riferimento alle cinque unità accademiche coinvolte nel progetto triennale i seguenti docenti hanno prestato in particolare la loro attività sia nelle scuole che nell'ambito dei corsi di dottorato.

- a) Università di Bergamo: il sottoscritto Giorgio Consigli, coordinatore del progetto, la prof.ssa Marida Bertocchi ed il prof. Vittorio Moriggia,
- b) Università di Vienna: il prof Georg Pflug ed il dr. Ronald Hochreiter,
- c) Università Brunel di Londra: prof Gautam Mitra, prof.ssa Diana Roman, prof.Csaba Fabian e dr Christian Valente,
- d) NTNU di Trondheim (NO): prof. Alexei Gaivoronski, prof. Asgeir Tomasgard e dr.ssa Adela Ppages-Bernaus
- e) Università di Edimburgo (UK): prof. Jacek Gondzio, prof. Andreas Grothey e dr. Marco Colombo.

I quindici docenti hanno interagito con relativa continuità nell'arco del triennio ed in occasione della conclusiva scuola del novembre del 2009 messo a punto un programma di lezioni ed esercitazioni al computer sui temi indicati a seguire di grande efficacia.

*A1. Spring School on Stochastic Programming: Theory and Applications – April 10-20, 2007 (cf appendice A)*

La scuola di programmazione stocastica organizzata dal dipartimento di MSIA dell'Università di Bergamo ha avuto luogo nell'aprile del 2007, da cui la denominazione di *Spring school*, ed ha avuto tra i suoi obiettivi specifici, l'avvio alle tematiche della PS di un vasto gruppo di studenti di dottorato e la sensibilizzazione di esponenti ed operatori dell'economia e dell'industria ai risultati della ricerca operativa avanzata e della programmazione stocastica in una molteplicità di ambiti operativi, come chiarito nell'appendice A. La scuola ha rappresentato un'iniziativa di riconosciuto valore e di grande successo, sottoponendo sia il corpo docente che quello amministrativo ad un impegno organizzativo notevole. Il successo di questa prima iniziativa del triennio ha aperto la strada naturalmente al buon esito degli eventi successivi e più in generale accreditato l'università di Bergamo come centro formativo di eccellenza nell'area dell'ottimizzazione anche in ambito internazionale.

La scuola, della durata di due settimane, si è articolata in lezioni estese di 60 minuti su elementi teorici completate da lezioni legate a specifici ambiti applicativi (finanza, energia, telecomunicazioni, e altre) ed a fine pomeriggio da tre relazioni svolte in presenza dei docenti dagli iscritti alla scuola. L'apertura di uno spazio qualificato per i giovani ricercatori e gli operatori ha seguito un modello affermatosi a livello europeo e teso ad accrescere e stimolare la partecipazione degli studenti in un contesto informale ed interattivo. La scuola ha anticipato di qualche mese il terzo simposio di Programmazione stocastica, un evento triennale organizzato nel 2007 dal professor Pflug, partner del network Cariplo, ponendosi quindi in ideale anticipazione allo stesso e rafforzandone la partecipazione.

*A.2 CARIPLO Workshop on Numerical Linear and Nonlinear Stochastic Programming – September 3-5, 2008 (cf Appendice B)*

Il simposio di programmazione stocastica del 2007 ha rappresentato un evento distribuito su cinque giorni di conferenza nel quale studiosi di tutto il mondo hanno presentato i risultati più recenti nelle diverse aree di approfondimento. L'università di Bergamo e gli altri partners Cariplo hanno partecipato attivamente, anticipando il successivo workshop del 2008, organizzato dalla scuola di matematica dell'università di Edimburgo e dal centro Carisma dell'università Brunel di Londra.

Il workshop, parimenti alle scuole del 2007 e 2009, ha beneficiato delle scholarships attribuite dagli organizzatori, coadiuvati dallo scrivente, a studenti provenienti dai diversi atenei e si è strutturato in relazioni estese da parte dei docenti del network Cariplo più altri della sede ospitante e brevi talks tenuti da parte dei dottorandi ed in generale da un insieme selezionato di afferenti all'evento.

I dettagli completi del workshop sono offerti nell'appendice B.

Un insieme esteso di relazioni tenute nella school del 2007, nel simposio di programmazione stocastica dell'estate del 2007 e del workshop del 2008 è confluita nel volume descritto in appendice D pubblicato da Springer-Verlag ed edito dallo scrivente coadiuvato dalla prof.ssa Bertocchi e dal prof.M.Dempster dell'università di Cambridge (UK).

Nei contenuti, come anche suggerito dalla denominazione adottata, il workshop ha espresso nel triennio Cariplo, un focus particolare sulle tematiche legate alla soluzione attraverso metodi numerici di problemi realistici di ottimizzazione stocastica.

### *A3. Stochastic Programming School 2009: Theory and Applications – November 23-28, 2009* (cf Appendice C)

Il modello formativo precedentemente richiamato ha avuto la sua realizzazione più compiuta nella scuola dello scorso autunno 2009. La settimana di studio si è strutturata in cinque giorni con lezioni al mattino, sezione al laboratorio e relazioni di giovani ricercatori nel pomeriggio. Le sezioni al laboratorio si sono susseguite secondo lo schema indicato nel grafico 1. Al termine dei cinque giorni i partecipanti hanno potuto *hands-on* familiarizzare con software dedicati alla formulazione e soluzione di problemi realistici di ottimizzazione. Nel sesto e conclusivo giorno della scuola quattro delle cinque università del network hanno presentato i risultati delle ricerche più recenti. Il prospetto che segue riepiloga nel merito l'evoluzione della scuola,

SPS 2009 at a glance					
	<b>Monday, November 23</b>	<b>Tuesday, November 24</b>	<b>Wednesday, November 25</b>	<b>Thursday, November 26</b>	<b>Friday, November 27</b>
	Methods and applications in dynamic stochastic programming	DSP mathematical specification and model generation	Approximation of stochastic programmes and financial applications	Stochastic programming applications in energy and ITC	Numerical methods for the solution of large scale SP problems
	<i>UniBG</i>	<i>CARISMA</i>	<i>UniVienna</i>	<i>NTNU</i>	<i>UnivEdinburgh</i>
9:30-11:00	Introduction to dynamic stochastic programming	Mixed integer programming, quadratic programming and extensions	Random processes approximation	Energy applications	Nonlinear optimization
11:15-12:30	Applications	Simulation and optimization	Financial applications	ITC applications	Interior point methods
	MEAL	MEAL	MEAL	MEAL	MEAL
<b>14:00-15:15</b>	<b>Lab I</b>	<b>Lab II</b>	<b>Lab III</b>	<b>Lab IV</b>	<b>Lab V</b>
<b>YOUNG RESEARCHERS TALKS</b>					
15:30-16:00	R. Toninelli: Stochastic Data Envelopment Analysis with scenarios generation technique	B. Flach: Stochastic Programming with Endogenous Uncertainty: an Application in Humanitarian Logistics	C. Vincent: A Distribution problem of Chance-Constrained Fractional Programming with General form of Distributions	J Blevins: Approximation Algorithms for Stochastic Quasi-Gradients: Sum and Max Rules	J Hubner: A Parallel Code Generator for Multistage Stochastic Programs
16:00-16:30	R. Ferstl: Asset-Liability Management Under Time-Varying Investment Opportunities	A.M.Pedersen: Integrated Mortgage Loan and Pension Planning	M. Branda: Reformulation of general chance constrained problems using penalty functions	A. Leiras : Operational planning under uncertainty of an oil refinery	N. Chiang: Solving Security Constrained Optimal Power Flow Problems by a Structure Exploiting Interior Point Methods
16:30-17:00	K. Emich: Airline network revenue management under uncertainty by Lagrangian relaxation	M.Poss: The Knapsack Problem With Gaussian Weights	F.S.Thomè: Decomposition technique with implicit multipliers evaluation in electrical expansion planning	R.Riccardi: Hierarchical Fleet Mix Problems with risk-aversion: a CVaR approach.	R. Khandouzi: Automotive Sale Price Forecasting at Iran Khodro Company Using a New Fast Global Neural
17:00-17:30		F. Oliveira: The development of a stochastic optimization model for the biodiesel supply chain based on small farmers	T.Sinotina: Universal confidence sets for the mode of regression function	L. Costa: Considering Reliability Constraints in the Power Systems Expansion Planning Problem	

**Tabella 1. Sintesi del programma di SPS2009**

Le lezioni del mattino e le sessioni al laboratorio rappresentano un patrimonio formativo acquisito per l'università di Bergamo e guiderà iniziative future consentendo il consolidamento del programma all'interno dei futuri cicli di dottorato (si veda sotto). Tra le presentazioni del pomeriggio da parte degli studenti da notare la prevalenza di applicazioni energetiche e la rilevanza di problemi di ottimizzazione anche atipici.

Le relazioni di sabato 28 novembre:

- a) Andreas Grothey, università di Edimburgo: Interior point warmstart for stochastic programming
- b) Alexei GaivoronSKI, NTNU: Stochastic programming models in ICT industry and economics
- c) Csaba Fabian, Brunel Londra: An enhanced model for portfolio choice with SSD criteria: a constructive approach
- d) Giorgio Consigli, uniBG: Individual ALM with intermediate targets and pension provisioning

## **II.B CORSI DI DOTTORATO -- *Metodi Computazionali per Previsioni Economiche e Finanziarie***

Il DMSIA dell'Università di Bergamo è sede di dottorato in *Metodi Computazionali per Previsioni Economiche e Finanziarie*.

Una parte delle risorse allocate dalla Fondazione è stata impiegata per invitare docenti stranieri anche non affiliati alle cinque unità accademiche principali, a tenere corsi nell'ambito del dottorato offerto dal Dip.to di matematica a cui afferisce il coordinatore del progetto e diretto dalla prof.ssa Marida Bertocchi. Il dottorato ha già una sua struttura ben definita e consolidata negli anni con un primo anno di studio e formazione, un secondo orientato ad approfondimenti di ricerca, tipicamente svolti all'estero, ed un terzo di ulteriore approfondimento e produzione scientifica ed orientata al conseguimento del titolo. I fondi Cariplo sono stati principalmente impiegati in questo ambito per offrire corsi legati ai temi dell'ottimizzazione stocastica, aggiuntivi rispetto a quelli classici. Gli studenti di dottorato del biennio 2007/08 e 2008/09 hanno quindi beneficiato di una formazione aggiuntiva in alcuni casi divenuta caratterizzante la successiva attività di ricerca. Ai corsi offerti hanno anche partecipato dottorandi di altre università italiane per il forte interesse nella materia. La tabella seguente fotografa i corsi offerti grazie al progetto, i docenti responsabili e l'estensione dei corsi nei due primi anni dei cicli di dottorato iniziati nel 2007-2008 e 2008-2009.

The 2007--2009 SPT4DSS CARIPLO project doctoral courses			
Period	Teacher	Topic	hours
<b>a.y. 2007-2008</b>			
apr-08	Prof.R.Hochreiter, VIENNA UNIV, Vienna (AT)	Scenario generation for stochastic programs	20 h
mag-08	Prof.A. Gaivoronski, NTNU Trondheim (NO)	Stochastic programming applications	12h
giu-08	Prof.L.M.MacLean, DALHOUSIE UNIV, (NO)	Mathematical Statistics in Finance	16h
nov-08	Prof.G.Owen, Naval Postgraduate School di Monterey	Game theory	4h
<b>a.y. 2008-2009</b>			
apr-09	Prof.G.Pflug, VIENNA UNIV, Vienna (AT)	Stochastic programming theory and financial applications	20h
mag-09	Prof.A.Tomasgard, NTNU Trondheim (NO)	Stochastic Programming applications in energy and logistics	20h
mag-09	Prof. J.Gondzio, EDINBURGH UNIV	Numerical methods for stochastic programmes	8h
giu-09	Dr.M.Colombo, EDINBURGH UNIV	Numerical methods for stochastic programmes	16h
giu-09	Prof. W.Ziemba, British Columbia University di Vancouver	Static portfolio theory, risk aversion, stochastic dominance, dynamic asset liability management	6h
lug-09	Prof.M.Biggs, Hatfield University - UK	Nonlinear Optimization with Financial Applications	35h

**Tabella 2: interventi docenti Cariplo nel dottorato in Metodi offerto da DMSIA-UniBG**

Nei contenuti attraverso i cicli di lezione tenuti, in particolare con riferimento alle applicazioni economiche e finanziarie, abbiamo inteso consolidare un percorso didattico avanzato strutturato in quattro parti:

- (i) Introduzione teorica e fondamenti di ottimizzazione stocastica,
- (ii) Modelli stocastici e rappresentazione dell'incertezza,
- (iii) Applicazioni e aspetti implementativi,
- (iv) Metodi numerici per la soluzione di problemi di programmazione stocastica.

Nel biennio maggiore enfasi è stata attribuita ad una piuttosto che all'altra area di approfondimento con una relativa differenziazione di contenuti.

Lo schema didattico affermatosi nel biennio sarà riproposto in futuro nell'ambito di un arricchimento dell'offerta formativa del dottorato. Emerge dalla tabella l'orientamento ad offrire inizialmente corsi seppure avanzati introduttivi all'ottimizzazione stocastica per poi introdurre aspetti applicativi e di natura algoritmica, in particolare con riguardo ai metodi di generazione e soluzione dei problemi di PS.

Il modulo tipico è strutturato in 20 ore per due settimane di corso.

Non entriamo in questa sede nella descrizione delle diverse aree di applicazione dei metodi di PS, lasciando la possibilità di approfondire nelle appendici.

### **III. PUBBLICAZIONI**

Due gli output principali del progetto Cariplo in termini di pubblicazioni scientifiche, nelle quali viene pubblicizzato il sostegno da parte della Fondazione.

La school del 2007, alcuni interventi da parte del corpo accademico per il 2008 e nel simposio di programmazione stocastica dell'estate 2007, hanno trovato sbocco in una proposta di volume alla Springer e successivamente inserito in una importante collana di Management science diretta dal prof.Hillier, figura di primissimo piano in ambito internazionale. Il volume è atteso completato entro l'estate del 2010 e dovrebbe beneficiare di una valida campagna di marketing da parte del Publisher. I capitoli del volume e la proposta nel suo complesso sono descritti nella appendice D alla presente relazione:

#### **A) STOCHASTIC OPTIMIZATION METHODS IN FINANCE AND ENERGY**

New financial products and strategies in liberalised energy markets, M.Bertocchi, G.Consigli and M.A.H.Dempster Eds

La proposta raccoglie i principali sviluppi applicativi nell'area della finanza e dell'energia ed è caratterizzata da un insieme di specificità, brevemente richiamate:

- Prima collezione di case-studies formulati e risolti come problemi di programmazione stocastica multistadio nei settori energetico e finanziario,
- Analisi estesa di nuovi prodotti finanziari ed associati problemi di ottimizzazione dinamica per investitori istituzionali quali Fondi pensione e Compagnie assicurative
- Overview di modelli di ottimizzazione e di equilibrio in mercati energetici liberalizzati
- Analisi integrata di elementi metodologici ed economici comuni per problemi applicati tipici di applicazioni in mercati competitivi quali quello finanziario ed energetico

- Descrizione di sistemi avanzati di supporto decisionale nei due contesti considerati.

Infine dobbiamo sottolineare come l'insieme di autori dei singoli capitoli esprima esperti – accademici e managers -- riconosciuti di chiara fama internazionale.

Il volume in tre parti contiene una prima parte dedicata alle applicazioni in ambito finanziario, una seconda a quelle in ambito energetico ed una terza di carattere teorico in cui si affrontano alcune problematiche comuni alle applicazioni di programmazione stocastica.

#### B) SPS2009 Proceedings, G.Consigli and G.Pflug Eds

La school conclusiva dell'autunno 2009 esprime a sua volta un insieme di articoli, attualmente in fase di raccolta i quali troveranno spazio in una special issue del Journal of Statistics and Decisions diretto dal prof Georg Pflug (cf appendice D.2) ed edito dal professor Pflug insieme allo scrivente. La special issue darà spazio al ruolo della Fondazione nel sostenere il progetto.

In questo secondo caso il journal includerà articoli di giovani ricercatori ed accademici afferenti al network Cariplo su applicazioni presentate nell'ultimo giorno della school.

Anche in questa pubblicazione, nella generale filosofia del progetto formativo, trovano spazio un insieme di applicazioni in ambito in questo caso non solo finanziario ed energetico, ed articoli orientati a chiarire sia i passaggi metodologici che le implicazioni teoriche di sviluppi destinati alla soluzione attraverso metodi numerici di problemi decisionali complessi in condizioni di incertezza.

#### **IV. MODELLO FORMATIVO E SINERGIE**

Il progetto per quanto già affermato ha rappresentato un periodo di crescita e grande scambio tra studenti e docenti provenienti da diversi contesti accademici e geografici, consentendo l'affermarsi di un contesto di collaborazione che certamente continuerà a produrre conseguenze positive nel futuro.

Il successo dei tre eventi principali e la possibilità di sostenere nostri studenti per periodi prolungati all'estero sono chiaramente da porre in relazione con i fondi raccolti, per la scuola del 2007 anche da enti privati ed associazioni e per i successivi eventi del 2008 e 2009 con le borse di studio CARIPOLO assegnate per consentire agli studenti di coprire una parte rilevante dei costi delle iniziative. Le borse sono state impiegate per finanziare in particolare le iscrizioni agli eventi, i costi di pernottamento ed i viaggi. Fino ad un massimo variabile a seconda dell'evento.



L'utilizzo della borsa di studio in particolare ai fini di copertura degli alloggi ha da un lato appesantito l'impegno organizzativo, dall'altro consentito di raggruppare giovani provenienti da zone diverse del mondo facilitando lo scambio e la conoscenza reciproca.

Sia la scuola del 2007 che quella del 2009 hanno rappresentato momenti di impegno per gli studenti e per i docenti in un modello formativo intenso seppure breve il quale ha consentito una frequentazione tra docenti e discenti continua con elevate ricadute anche formative.

Il modello: lezioni teoriche ed applicative frontali, sezioni al laboratorio e spazio per le relazioni degli studenti in un consesso fortemente qualificante è risultato sicuramente vincente. Il sostegno da parte della Fondazione Cariplo ha consentito tutto ciò in larga misura e se mi è consentito gli obiettivi iniziali sono stati pienamente raggiunti.

Le borse di studio sono state assegnate in generale sulla base di alcuni criteri selettivi, una volta definito il numero massimo di borse erogabili da parte degli organizzatori, al fine di agevolare gli studenti in primis provenienti dalle università del network riservando ad essi un certo numero di borse e poi beneficiando sulla base del curriculum studi ed in base alla priorità di iscrizione. A parità di altri criteri venivano inoltre agevolati gli applicants provenienti da paesi più lontani. In tal senso particolarmente interessante il gruppo di studenti provenienti dall'America Latina, dalla Cina e dall'Australia.

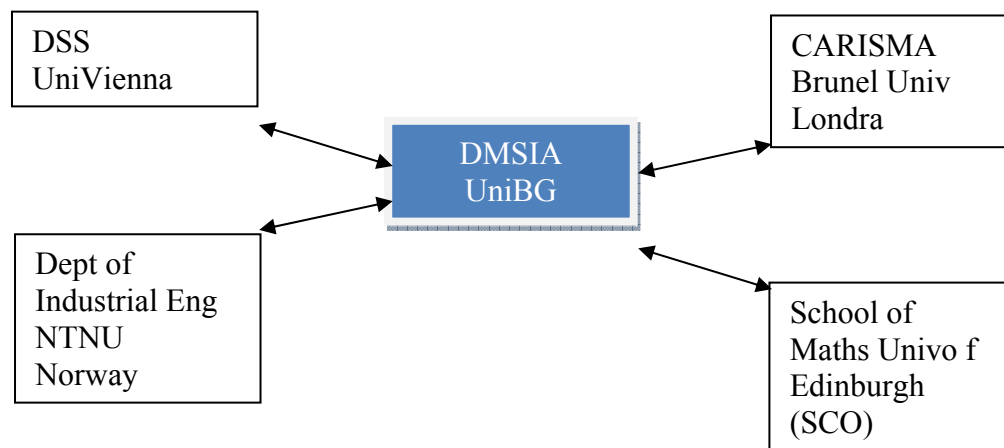
#### **IV.A LE UNIVERSITA' DEL NETWORK**

Il progetto CARIPLO ha rappresentato per lo scrivente coordinatore del network uno sforzo organizzativo significativo distribuito nel triennio coronato altresì da risultati positivi. Le cinque unità accademiche di riferimento hanno collaborato sia con finalità formative sia consentendo periodi di permanenza nelle proprie sedi ed infine per ragionare sulle potenzialità di un modello educativo su materie avanzate distribuito nel tempo e nello spazio. Il DMSIA dell'università di Bergamo ha rappresentato il centro di coordinamento ed il beneficio principale dell'iniziativa di internazionalizzazione è andata a studenti e dottorandi del nostro Ateneo.

Come precedentemente richiamato i Dipartimenti coinvolti hanno maturato nel tempo competenze e specializzazioni tra loro contigue ed in tal senso, già prima del presente progetto, avevano avviato forme di collaborazione sporadiche. Il periodo 2007-2009 ha quindi consentito uno scambio mirato con ciascuno dei dipartimenti stranieri in particolare con finalità didattiche e di formazione avanzata (in tal senso quindi espressive degli obiettivi di ricerca perseguiti) sulle seguenti tematiche:

- DSS di Vienna: teoria dell'approssimazione dei processi stocastici e generazione degli scenari,
- Carisma di Londra: generazione modelli, metodi risolutivi e software development
- NTNU di Trondheim (NO): applicazioni in ambito energetico, TLC e logistico
- Università di Edimburgo: algoritmi e metodi numerici per la soluzione di problemi anche di grandi dimensione lineari e nonlineari

Si conferma in tal senso lo schema sinergico che il proponente intendeva affermare con il progetto:



Le sinergie tra le diverse unità hanno trovato quale principale output la realizzazione di un area di e-learning presso l'università di Bergamo strutturata a partire dalle due esperienze del 2007 e 2009. Nell'ultima edizione come detto le cinque unità hanno collaborato al fine di realizzare un insieme di moduli informatici tesi ad accompagnare sulla base di semplici case-studies i frequentatori nei singoli passaggi relativi alla definizione e soluzione di problemi decisionali multistadio di natura stocastica.

#### **IV.B SINERGIE UNIVERSITA'-IMPRESA**

Il progetto CARIPLO ha consentito in forza della natura fortemente applicata e multidisciplinare della materia di verificare su percorsi formativi avanzati le problematiche legate all'impiego

delle metodologie insegnate in ambito operativo. Il mondo dell'impresa è stato presente sia attraverso forme di sostegno finanziario sia nello sviluppo di casi concreti discussi con gli studenti, legati all'impiego di strumenti tipici dell'ottimizzazione. In particolare nel primo anno del progetto, lo scrivente ha tenuto un ciclo di lezioni ed introduzioni sia presso società finanziarie che nell'ambito di associazioni professionali. La CONFINDUSTRIA di Bergamo attraverso la ProUniversitate Bergomensis ha sponsorizzato la scuola del 2007.

La Dalmine Energia ha indirizzato propri rappresentanti alle diverse iniziative formative. Parimenti società del gruppo Monte dei Paschi di Siena e UniCredito Italiano hanno frequentato le scuole del 2007 e 2009.

La scuola ha attivato un insieme significativo di sinergie primariamente a beneficio di studenti alla ricerca di sbocchi professionali in ambito finanziario e nel settore energetico. Le scuole del 2007 e 2009 hanno consentito scambi mirati di confronto e conoscenza reciproca tra figure fortemente professionalizzate del mondo dell'impresa e dottorandi impegnati nella formalizzazione di problemi complessi tipicamente di ricerca operativa.

In termini generali e con riferimento ad una duratura politica di trasferimento tecnologico dall'accademia all'impresa permangono un insieme di difficoltà che è forse opportuno richiamare:

- L'impiego di modelli di ottimizzazione in ambito aziendale incontra difficoltà legate in certa misura al carattere normativo erroneamente attribuito alle indicazioni raccolte: le strategie ottime rappresentano altresì una base informativa orientata ad arricchire ed orientare i processi decisionali, non determinarli.
- L'adozione di strumenti decisionali avanzati non può non essere coniugata con l'implementazione di criteri di validazione facilmente fruibili e condivisi con il management delle aziende interessate: ad oggi l'interazione tra il mondo accademico ed il settore delle aziende continua a soffrire l'assenza di politiche territoriali efficaci.
- L'acquisizione del know-how offerto in particolare nell'ambito del progetto in ambito aziendale richiede la realizzazione di un contesto collaborativo tipicamente di medio-lungo termine: un orizzonte temporale spesso di difficile acquisizione in contesti orientati alla competizione di mercato.
- Nella scuola del 2009 in particolare l'unità di Bergamo ha potuto beneficiare di più di un anno di collaborazione con una primaria realtà finanziaria internazionale: l'esistenza di

un rapporto in certa misura consolidato favorisce il trasferimento di know-how dal mondo accademico a quello delle imprese, difficile da ipotizzare.

L'ultima osservazione in particolare suggerisce, qualora si intenda dare tale finalità ad iniziative future, percorsi formativi i quali si sviluppino da casi concreti condivisi nei diversi ambiti operativi. Un obiettivo perseguito ma non centrale nel presente progetto. Rilevante e positiva è stata la realizzazione delle capacità di soluzione di una molteplicità di problemi applicativi da parte dei metodi di PS: questo anche rappresenta un significativo risultato delle due scuole del 2007 e 2009.

## **V. CONSIDERAZIONI CONCLUSIVE**

Il progetto di formazione d'eccellenza qui descritto è stato reso possibile dal significativo contributo della Fondazione CARIPLO. Essa ha concorso per il 50% a finanziare unitamente all'Ateneo, alle altre università del network, a realtà associative scientifiche ed aziendali, ed infine a sponsors aziendali un insieme di eventi limitato nel numero ma di grande impatto sia in ambito locale che internazionale.

Gli obiettivi formativi perseguiti hanno ruotato intorno ai temi dell'ottimizzazione stocastica applicata alla soluzione di problemi di pianificazione strategica. Il successo del progetto è in larga misura spiegabile a nostro avviso dai seguenti fattori:

- (i) La natura applicata e fortemente multidisciplinare dell'area scientifica interessata: gli studenti hanno attraverso i corsi approfondito le proprie conoscenze di ricerca operativa, teoria dei processi stocastici, pianificazione finanziaria, algoritmi e metodi risolutivi in stretta connessione con casi concreti ed applicati;
- (ii) La capacità di concentrare su periodi delimitati e di intenso scambio scientifico un numero rilevante di esperti del mondo accademico a partire dai colleghi delle università del network: la disponibilità all'interazione ed allo scambio didattico ha beneficiato tutte le iniziative prese;
- (iii) L'indicazione chiara degli sbocchi operativi ed applicati di risultati teorici anche avanzati e spesso slegati da uno specifico contesto di applicazione;
- (iv) L'apertura ad un contesto multilingue ed internazionale di grande rilevanza: ciò è testimoniato dai numeri e dall'estensione delle aree geografiche interessate in particolare ai tre eventi. Un tale risultato non sarebbe stato possibile senza il forte

contributo offerto dalle *scholarships* CARIPLO. La Fondazione ha in tal senso acquisito una visibilità ed un riconoscimento ampio ed unanime;

- (v) Infine il forte spirito collaborativo tra i membri del Dipartimento direttamente coinvolti e le unità amministrative e del Presidio di Economia dell'università di Bergamo ha rappresentato un fattore di crescita interna, apertura nei confronti dell'Ateneo nel suo complesso e consolidamento di capacità organizzative e scambio con realtà internazionali di grande valore e riconoscibilità.

A conclusione di questa relazione, mi permetto di anticipare l'intento che spero sia reso possibile dal contributo della Fondazione di rendere permanente l'organizzazione di un evento quale quello del 2009 con una frequenza da definire.

Prof. Giorgio Consigli  
Responsabile e Coordinatore progetto  
CARIPLO Modelli e Tecniche  
Ottimizzazione Stocastica SPT4DSS

# APPENDICE A. LA SCUOLA DI OTTIMIZZAZIONE DEL 2007

## PRESENTAZIONE E CARATTERISTICHE PRINCIPALI

10 - 20 APRIL 2007  
UNIVERSITÀ DEGLI STUDI DI BERGAMO  
WWW.UNIBG.IT/SPS2007  
E-MAIL: [SPSCHOOL2007@UNIBG.IT](mailto:SPSCHOOL2007@UNIBG.IT)  
==> [E-LEARNING](#)

### Project Topic and Objectives

We propose an advanced programme from April 10 (Tuesday, after Easter) to April 20, 2007 (Friday), based on 10 half days of lecturing completed every afternoon by a set of presentations by young researchers and practitioners. The initiative is oriented to researchers, doctoral students and practitioners with a general aim to attract a significant audience to a key and rapidly growing area of mathematical programming.

The school aims also at establishing a qualified venue to enhance and promote the understanding by young scientists of the potentials of applied stochastic optimisation in areas such as finance, production planning, energy, telecommunications and clarify to leading practitioners the current state of the art in the development of stochastic optimisation techniques.

The proposal comes at a point in which the potentials of stochastic programming techniques in applied decision theory are becoming fully recognised in the industry, and the demand for advanced education programmes in this area is growing.

### Scientific Originality

The conjunction of operations research methods, stochastic modelling and probability theory has been primarily associated with the seminal contributions of George Dantzig (1955, 1959) in the area of decisions theory under uncertainty leading to the first models of stochastic optimization in problems of military and defence. Since then a remarkable scientific effort in the fields of mathematical programming techniques, stochastic processes theory and computer science has facilitated on one side the adoption of increasingly powerful solution techniques to high dimensional decision problems and on the other side the accurate inclusion of alternative models of uncertainty in a wide range of dynamic management problems. The development is well documented and summarised in the web site [www.stoprog.org](http://www.stoprog.org), the fundamental scientific link of the community. The growing success of the Stochastic Programming symposia held every three years, alternatively in the US and Europe – last in Tucson Arizona in 2004 and next in Vienna, August 2007 –, is one of the motivations of our initiative, as further explained in the sequel.

The growing spectrum of application areas is now pushing for further developments and the solution of previously unforeseeable theoretical and applied problems.

Specifically in the areas of

- Finance, related to the ongoing liberalisation process and the relationship between economic growth and demand for new financial instruments (pension funds, insurance, asset-liability management);
- Energy and environment, also related to the liberalisation of the electricity market and the growing concern of the environmental consequences of the generally adopted economic development system;
- Telecommunications, application of advance network technologies with complex input-output structures;
- Production planning in the industrial sector, also growingly dependent on widely recognised as random inputs and outputs;

and several others.

A common feature of the above problem classes is their dependence on possibly complex stochastic dynamics and the inclusion of different types of risk-reward tradeoffs in the objective functions, easily leading to large-scale decision problems.

More recently the advances in the theory of risk, leading to the establishment of an axiomatic theory of risk measures, has further enhanced the understanding of the implications of alternative risk measures in decision planning problems under uncertainty.

The explicit inclusion of several thousand possible economic scenarios upon which an optimal decision strategy will depend calls for the adoption of high performance computing in the generation and solution of the associated optimization problem.

Finally the inclusion of chance constraints and integer variables may often required the formulation of the problem as a large scale mixed integer problem, whose solution will require dedicated numerical techniques.

The school is primarily proposed in order to attract and form a large number of promising young researchers and practitioners in the area of stochastic optimization and also give them the opportunity to present their research in a highly qualified venue. The two weeks training has been structured in order to facilitate the learning process from a theoretical and applied point of view and help an effective knowledge transfer between scholars in the field, young researchers and practitioners.

### **The Spring School Program**

We propose two intense weeks of training plus a sequence of afternoon sections devoted to presentations by school attendants.

The programme combines theory and applications in finance, energy, telecommunications, production planning and other application areas where dedicated developments did recently took place. Theoretical lectures are essentially proposed in the morning and the afternoons are left to lectures strictly related to different application fields and young researchers presentations.

As further clarified in section 3.1, the school has been structured in order to cover topics in the following streams:

- Stochastic optimization, introduction and key results, primal and dual theory
- Scenario generation and approximation of stochastic processes
- Integer, mixed integer, chance constrained, non standard linear and non linear stochastic programming
- Stochastic control and dynamic stochastic programming
- Model generation and solution methods for different problem classes

Theoretical sessions are finally linked to the different application areas by a number of lectures specifically addressing the numerical implications of different modelling approaches.

To enhance the attendant's interests and promote a discussion on several key aspects of stochastic programming applications, we propose a number of specific lectures in which the future of stochastic programming developments is discussed in a critical way, and possible ways forward presented from different perspectives. In this specific context prof. Vladimirou will present his view on future SP developments in finance, prof. Tomasgard on system developments and user requirements, prof. Dempster on application fields and model developments, prof. Dupacová on non-standard SP techniques, prof. Gaivoronsky on software developments from different application areas. In order to facilitate the interaction with the students, a group of local (from the organising committee) and foreign scholars will be present beyond the required teaching days. Prof. Pflug, main organiser of the Stochastic Programming symposium to be held in Vienna in August 2007 ([www.spxi.org](http://www.spxi.org)) is cooperating in order to maximise the synergies with the proposed school.

- [List of Speakers](#)

### **Young Researchers Contributions**

The School will leave space every afternoon to theoretical and applied contributions (three per day, for a total of 27 talks over the entire program period) by young researchers and practitioners attending the school in the general domain of *Decision making under uncertainty* related to:

- Mathematical programming and dynamic optimisation in particular
- Two-stage and multistage stochastic programming
- Stochastic control
- Dynamic risk measures
- Model generation and software developments
- Solution techniques for linear and nonlinear programmes
- Sampling techniques for large scale problems
- Output analysis for large-scale decision problems.

Submitted papers, in the spirit of the school, can be theoretical or, preferably, addressing decision and valuation problems in application areas such as economics and finance, energy, telecommunications, industry, system biology etc.



Unpublished articles or [extended abstracts](#) must be submitted **before January 31, 2007** to [spschool2007@unibg.it](mailto:spschool2007@unibg.it) following the scheme in the web page. Acceptance will be given shortly after the deadline.

Accepted papers will be included in the program by subject, following the school evolution.

## **The School Schedule**

The two-week course is based daily on four extended 60-minute lectures on “Theory and Applications” of stochastic programming to be held at 9:00 am, 10:00 am, 11:30 am and 2:00 pm, and three 40-minute talks starting at 3:15 pm (see the program at a glance at the end of this section).

### **WEEK 1**

#### **APRIL 10, Tuesday**

##### Session I. Fundamentals of stochastic optimization

Georg Pflug: Introduction to Stochastic Optimization: theory and applications

Georg Pflug: Optimality and Duality in stochastic programming

##### Session II. Applications in Finance 1

Nikolas Topaloglou: Enterprise wide risk management

Hercules Vladimirov: Dynamic portfolio management

#### **3,15-5,30 PM: *YOUNG RESEARCHERS PRESENTATIONS***

#### **APRIL 11, Wednesday**

##### Session III. Scenario generation and approximation methods

Ronald Hochreiter: Approximation of stochastic processes in SP applications

##### Session IV. Applications in Finance 2

Andrea Consiglio: Derivative pricing in incomplete markets

Matteo Germano: Pension fund management

Hercules Vladimirov: Current trends in the financial industry, the future of SP applications

#### **3,15-5,30 PM: *YOUNG RESEARCHERS PRESENTATIONS***

#### **APRIL 12, Thursday**

##### Session V. Mixed integer and chance constrained stochastic programming

Laureano Escudero: Mixed integer stochastic programming: theory and applications

Maarten van der Vlerk: Stochastic integer programming

René Henrion: Chance-constrained stochastic programming

##### Session VI. Stochastic programming developments 1

Janos Mayer: Model generation and solution algorithms for multistage stochastic programming

**3,15-5,30 PM: YOUNG RESEARCHERS PRESENTATIONS**

**APRIL 13, Friday**

Session VII. Stability

Jitka Dupačová: Stochastic programming under non-standard assumptions  
Werner Römisch: Stability of stochastic programming problems

Session VIII. Applications in the Energy Sector 1

Asgeir Tomasgaard: Energy management in the gas sector  
Pierluigi Riva: Statistical methods for energy demand and supply

**3,15-5,30 PM: YOUNG RESEARCHERS PRESENTATIONS**

**APRIL 14, Saturday**

Session IX. Stochastic programming advances

S.P. Mukharjee: Stochastic programming with random decision variables

Session X. Applications in the Energy Sector 2

Yves Smeers: Convex stochastic equilibria in the electricity market  
Chefi Triki: Portfolio Optimization for Electricity Traders  
Fabio Leoncini: TBD

**WEEK 2**

**APRIL 16, Monday**

Session XI. Dynamic stochastic programming

Michael A.H. Dempster: Multistage stochastic programming: algorithms and applications

Session XII. Applications in Economics

Stavros Zenios: Practical stochastic optimization: applications in economics and finance  
William T. Ziemba: Intertemporal surplus management

Session XIII. Stochastic programming developments 2

Elena Medova: STOCHASTICS™ - Model development for SP Applications

**3,15-5,30 PM: YOUNG RESEARCHERS PRESENTATIONS**

**APRIL 17, Tuesday**

Session XIV. Linear stochastic programming

Carlo Acerbi: Risk measures in stochastic optimization  
Gautam Mitra: Formulation and solution of large scale SP problems

Session XV. Emerging SP Application areas

Enza Messina: Systems biology  
Francesco Archetti: Ambient Intelligence

**3,15-5,30 PM: YOUNG RESEARCHERS PRESENTATIONS**

**APRIL 18, Wednesday**

Session XVI. Nonlinear stochastic programming

Jacek Gondzio: Introduction to nonlinear stochastic programming

Jacek Gondzio: Solution methods for large-scale nonlinear stochastic programming problems

Session XVII. Industrial Applications 1

Pavel Popela: Stochastic programming methods in engineering production

Pavel Popela: Supply chain management

**3,15-5,30 PM: YOUNG RESEARCHERS PRESENTATIONS**

**APRIL 19, Thursday**

Session XVIII. Stochastic programming and stochastic control

Elio Canestrelli: Multistage stochastic programming and stochastic control problems

Diana Barro: Stochastic control and MSP solution methods: applications in economics and finance

Session XIX. Industrial Applications 2

Alexei Gaivoronski: SP developments in Telecommunications

Paolo Brandimarte: Stochastic programming methods for Production planning

**3,15-5,30 PM: YOUNG RESEARCHERS PRESENTATIONS**

**APRIL 20, Friday**

Session XX. Postoptimality and output analysis

Marida Bertocchi: Postoptimality analysis SP problems

Alexei Gaivoronski: Output analysis for large-scale SP solution files

Session XXI. SP into the future

Giorgio Consigli: The future of SP software development

Giorgio Consigli: State of the art and foreseeable SP applications

**3,15-5,30 PM: YOUNG RESEARCHERS PRESENTATIONS**

**Organisation and Management**

The **Organising Committee** is based in Bergamo (Italy) and formed by

Giorgio Consigli (Main organiser, University of Bergamo)

Marida Bertocchi (University of Bergamo, IT)

Vittorio Moriggia (University of Bergamo, IT)

Elisabetta Allevi (University of Brescia, IT).

**Pioneer Investments**, one of the largest Fund managers worldwide with a definite and strong applied research vocation, will support the SP school through the *accommodation sponsorships*

Pioneer representatives will be given the opportunity to present the Group activity (primarily based in Milan, Dublin and Boston) to the school attendants and interview selected young researchers and doctoral students attending the school, to be considered, in full coordination with the respective University supervisors and academic coordinators, for inclusion in their high potential human resource database. School attendants with an interest in a finance career are required to send their CV's, including for knowledge their academic supervisors, to [spschool2007@unibg.it](mailto:spschool2007@unibg.it) expressing an interest to be interviewed.

We are also glad to inform that **OptiRisk Systems** ([www.optirisk-systems.com](http://www.optirisk-systems.com)), as part of CARISMA participation to the school, has agreed to offer a 6 month license of SAMPL/SPInE to the school attendants. During the school those who intend to take advantage of this opportunity will have to fulfil an application form available at the organization desk. OptiRisk Systems offers products and services ([www.optirisk-systems.com/products](http://www.optirisk-systems.com/products)) in the area of Optimisation, Risk Modelling, Portfolio Planning, Asset and Liability Management, Supply Chain Management, Strategic & Tactical Management, Scheduling of Transport. We acknowledge and thank the UK-based company run by Professor Mitra and his colleagues at Brunel University, to give this important opportunity to SPS2007 attendants.

## Sponsorships

Our school is underwritten by Scientific Contributors and Corporate Affiliates. We're grateful to all of our sponsors for their generous support. For information on sponsorship opportunities, please [email us](#) for further information.



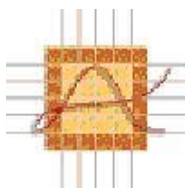
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**Associazione  
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[www.unindustria.bg.it/restyling/servizi/formazione/pagine/prouniversitate.jsp](http://www.unindustria.bg.it/restyling/servizi/formazione/pagine/prouniversitate.jsp)



**fondazione  
cariplo**

[www.fondazionecariplo.it](http://www.fondazionecariplo.it)

The school is endorsed by



**The Stochastic Programming Community**

[www.stoprog.org](http://www.stoprog.org)



**Italian Federation of Applied Mathematics**

[www.fimaonline.it](http://www.fimaonline.it)



[www.optirisk-systems.com](http://www.optirisk-systems.com)

## **Location and Infrastructure**

The Faculty of Economics of the University of Bergamo – [www.unibg.it/economia](http://www.unibg.it/economia) – provides an ideal environment for the school. A modern building realised roughly 10 years ago with fully computerised classrooms and a conference room. Depending on the attendance we can easily accommodate from 50 to 150 students during the proposed period. Lunch breaks will be organised by the faculty *mensa* in the same location.

A number of hotel and B&B accommodations are also available in the neighbourhood of the school location at agreed rate (for all details and required registrations see the [Accommodation List](#)).

- [Trains and Buses from the Airports to Bergamo](#).

## **European Added Value of Topic**

The proposal of the School comes at a point in which the potentials of stochastic programming

demand for advanced education programmes in this area is growing. The growing spectrum of application areas is now pushing for further developments and the solution of previously unforeseeable theoretical and applied problems. Specifically in the areas of finance – related to the ongoing liberalisation process and the relationship between economic growth and demand for new financial instruments (pension funds, insurance, asset-liability management) –, energy and environment – also related to the liberalisation of the electricity market and the growing concern of the environmental consequences of the generally adopted economic development system –, production planning – in the industrial sector, also growingly dependent on widely recognised as random inputs and outputs –, and several others. For the first time, thanks to the Institute, internationally recognised scholars, students and practitioners will be given the opportunity over an extended period of time in a truly multidisciplinary venue, to deepen their knowledge and exchange views and suggestions in order to enhance the understanding and confidence on the potentials of an applied field whose benefits to effective decision making are still to be fully understood.

### **European Added Value of Participants**

Stochastic programming is almost by definition a field at the conjunction of optimisation theory, stochastic processes and probability theory and decision theory under uncertainty. Participants will gain enormous insights in different application areas and at the same time be confronted with the challenges coming from the industry and the deep theoretical results of stochastic optimisation theory with implications on valuation theory, dynamic decision making and economic and financial planning.

We also aim with this initiative to strengthen and enlarge the area of young researchers interested in the subject of stochastic optimisation, that we see at the heart of scientific development from a computational and optimisation viewpoint.

## APPENDICE B. Il Workshop di Edimburgo del 2008

### CARIPLO Workshop on Numerical Linear and Nonlinear Stochastic Programming

Sep 3, 2008 - Sep 5, 2008

Ashworth Building, King's Buildings, University of Edinburgh

#### Organisers

Name	Institution
Cartis, Coralia	University of Edinburgh
Colombo, Marco	University of Edinburgh
Gondzio, Jacek	University of Edinburgh, School of Mathematics
Grothey, Andreas	University of Edinburgh, School of Mathematics



#### Keynote Plenary Lectures given by:

Giorgio Consigli, University of Bergamo, Italy  
Michael Dempster, University of Cambridge, UK  
Gautam Mitra, Brunel University, UK  
Georg Pflug, University of Vienna, Austria  
Alex McNeil, Heriot-Watt University, UK  
Marc Steinbach, University of Hannover, Germany

This workshop aims to bring together, for training and networking purposes, PhD students, young researchers and experts in these diverse aspects of numerical linear and nonlinear stochastic programming.

Many real-life problems involve uncertainty in their data, such as portfolio optimisation with uncertain future asset prices, utility distribution with uncertain demand, or robust network design with uncertain reliability of links. Stochastic programming is a popular approach to decision making under uncertainty, leading to very large-scale problems with challenging solutions. It is also highly interdisciplinary, involving researchers that work on scenario generation, computational and theoretical linear and nonlinear optimization and modeling. The focus of the workshop is to present and discuss in an accessible manner promising mathematical and computational avenues for tackling the current challenges in this area.

#### Scientific committee

Giorgio Consigli, University of Bergamo (Italy)  
Jacek Gondzio, University of Edinburgh (UK)  
Andreas Grothey, University of Edinburgh (UK)  
Gautam Mitra, Brunel University (UK)  
Georg Pflug, University of Vienna (Austria)  
Alexei Gaivoronski, University of Trondheim (Norway)

#### Programme

The workshop will be structured into plenary lectures (of 1h each) that give an overview over the various

aspects of numerical linear and nonlinear stochastic programming and sessions of contributed talks by conference participants (of about 30min each).

### Scholarships

25 scholarships for a value of up to EUR300 each, to cover travel, accommodation and registration costs are available from the Cariplo foundation through the University of Bergamo. Participants interested in these scholarships should send an abstract of their talk and a short CV to:

Giorgio Consigli ([giorgio.consigli@unibg.it](mailto:giorgio.consigli@unibg.it)) or  
Andreas Grothey ([A.Grothey@ed.ac.uk](mailto:A.Grothey@ed.ac.uk))

Please do not use the application form on this page to apply for a scholarship. Applications will be processed as they arrive. The closing date for sponsorship applications is 15 June 2008. Successful sponsorships will be communicated at the latest 4 weeks after their submission. The registration fee will be automatically deducted from the award and the remainder will be refunded after the event. Receipts will be required.

### Supporting institutions

This workshop is supported by the Cariplo Foundation [website](#), as part of a network of stochastic programming research and training meetings, with the first edition being held at the University of Bergamo (Spring School in Stochastic Programming [website](#)).

Other sponsors include:

[OptiRisk](#)

[CARISMA](#)

[Edinburgh Mathematical Society](#)

[Glasgow Mathematical Journal Trust](#)

[Cariplo Foundation](#)

[Maxwell Institute](#)

### Arrangements

#### Venue

[Lecture Theatre 3, Ashworth Building](#), Kings Buildings, [University of Edinburgh](#). Lecture Theatre 3 (Room 1.107) is located on the first floor of the Ashworth Building, accessed via Gateway 2 from West Mains Road. It can seat 88 and contains an XGA data projector, a dedicated PC, facilities for laptop input, DVD/VCR playback facilities, a visualiser, a PA radio mic, a stereo amp, audio record facilities, a 400W OHP, a 35mm slide projector, a laser pointer, an induction loop, two screens and a whiteboard.

#### Participation

You may register your interest in attending this meeting by completing the [application form](#) on this page. Please note that this form will close on 15 August 2008. After you have completed the form you will receive an e-mail with instructions on how to pay the registration fee (see below). You will only be accepted as a participant once payment has been received.

If you do not receive an e-mail please contact [Irene Moore](#).

#### Financial arrangements

There will be a registration fee of 100.00 GBP, payable by all participants.  
Late registration (from 1 August 2008): 150.00 GBP.

#### Accommodation

You are asked to reserve your own accommodation.

A list of Edinburgh accommodation of various sorts and prices is detailed below:

**Edinburgh First**, The University of Edinburgh, 18 Holyrood Park Road, Edinburgh EH16 5AY

0800 028 7118      0800 028 7118 (UK only) -      +44 (0)131 651 2189      +44 (0)131 651 2189

- [edfirst1.ednet.co.uk](http://edfirst1.ednet.co.uk)

*Edinburgh First offers a range of accommodation from standard single to twin en-suite rooms.*

**The Northumberland Hotel**, 31-33 Craigmillar Park, Edinburgh EH16 5PE

+44 (0)131 668 3131      +44 (0)131 668 3131 [website](#)

**St Christophers Hostel**, 9-13 Market Street, Edinburgh EH1 1DE

+44 (0)20 7407 1856      +44 (0)20 7407 1856 - [www.st-christophers.co.uk](http://www.st-christophers.co.uk) - [bookings@st-](mailto:bookings@st-christophers.co.uk)

[christophers.co.uk](http://christophers.co.uk)

Other accommodation can be found at this [link](#)



### Meals and refreshments

Coffee will be available during dedicated breaks opposite the Lecture Theatre. Please note that this room will only be available during breaks as it is used at all other times.

Lunch vouchers will be provided at registration. These will allow participants to purchase lunch, on Wednesday, Thursday and Friday, at KB House.

A wine reception and buffet will be held in the [Raeburn Room](#) at [Old College](#) on Wednesday evening followed by a guided tour of Edinburgh.

The workshop dinner will be held at [Blonde](#), 75 St. Leonard's Street, Edinburgh on Thursday evening. Directions to all the above will be included in your registration booklet.

### Organising committee

Andreas Grothey (chairman)

Coralia Cartis

Marco Colombo

Jacek Gondzio

## Programme

### Wednesday 3 September

08.30 - 08.55	Registration
08.55 - 09.00	Welcome address
09.00 - 10.00	Plenary talk: Georg Pflug (University of Vienna) The mathematics of scenario generation
10.00 - 10.30	Coffee/Tea
	Contributed talks session - Applications
10.30 - 10.55	Cristina Corchero (Universitat Politecnica de Catalunya) <i>Stochastic optimal day-ahead bid with physical future contracts</i>
10.55 - 11.20	Saverio Giuliani (University of Foggia) <i>A stochastic programming approach for strategic planning with activity based costing</i>
11.20 - 11.45	Thomas Surowiec (Humboldt University Berlin) <i>Analysis of M-stationary points and solutions to an SEPEC modeling oligopolistic competition</i>
11.45 - 12.10	Xinan Yang (University of Edinburgh) <i>Modelling and solving the stochastic top-percentile pricing problem by dynamic technique</i>
12.10 - 12.35	Chris Dent (University of Edinburgh) <i>The security constrained optimal power flow -- not a stochastic optimisation problem</i>
12.35 - 13.45	Lunch
13.45 - 14.45	Plenary talk: Michael Dempster (University of Cambridge) <i>Solution techniques for large scale dynamic stochastic programming problems</i>
14.45 - 15.15	Coffee/Tea
15.15 - 16.30	Contributed talks session - Integer and Global
15.15 -	Uwe Gotzes (University of Duisburg-Essen)

15.40	<i>Increasing convex order constraints induced by mixed integer linear recourse</i>
15.40 - 16.05	<b>Thong Nguyen Huu (Ho Chi Minh City University of Pedagogy)</b> <i>A new stochastic algorithm for optimization problems</i>
16.05 - 16.30	<b>Dimitri Drapkin (University of Duisburg-Essen)</b> <i>A cutting plane algorithm for optimization problems with stochastic order</i>
17.30 - 19.00	Wine reception and buffet in the Raeburn Room, Old College, University of Edinburgh
19.00 - 20.00	Guided tour of Edinburgh

#### Thursday 4 September

09.00 - 10.00	Plenary talk: <b>Gautam Mitra (Brunel University)</b> <i>Software tool for decision making under uncertainty: a combined paradigm of SP and simulation</i>
10.00 - 10.30	Coffee/Tea
10.30 - 12.30	Contributed talks session - Finance
10.30 - 10.55	<b>Csaba Fabian (Kecskemet College and Eotvos Lorand University)</b> <i>An enhanced model for portfolio choice with SSD criteria: a constructive approach</i>
10.55 - 11.20	<b>Sona Kilianova (Comenius University)</b> <i>On solving some problems of dynamic stochastic programming by means of stochastic dynamic programming</i>
11.20 - 11.45	<b>Anne Marie Boiden Pedersen (University of Copenhagen)</b> <i>Integrated mortgage loan and pension planning</i>
11.45 - 12.10	<b>Alessandro Staino (University of Palermo)</b> <i>A stochastic programming approach to the optimal insurance of government bonds</i>
12.10 - 12.35	<b>David Wozabal (University of Vienna)</b> <i>A new method for Value-at-Risk constrained optimization using the difference of convex algorithm</i>
12.35 - 13.45	Lunch
13.45 - 14.45	Plenary talk: <b>Marc Steinbach (Leibniz Universität Hannover)</b> <i>Interior point algorithms for nonconvex multistage stochastic programs</i>
14.45 - 15.15	Coffee/Tea
	Contributed talks session - Algorithms
15.15 - 15.40	<b>Martin Branda (Charles University in Prague)</b> <i>Software for multistage stochastic linear programming problems</i>
15.40 - 16.05	<b>Kian Ping Chan (Imperial College London)</b> <i>An iterative primal-dual aggregation algorithm for multi-stage stochastic quadratic programs</i>
16.05 -	<b>Marco Colombo (University of Edinburgh)</b>

16.30	<i>OOPS: A structure-exploiting parallel solver</i>
16.30 - 16.55	<b>Kristian Woodsend (University of Edinburgh)</b> <i>A structure-conveying modelling language</i>
16.55 - 17.10	Break
	Contributed talks session - Scenario Generation
17.10 - 1735	<b>Gaetano laquinta (University of Bergamo)</b> <i>A forward method for scenario generation with linear and nonlinear stochastic programs</i>
17.35 - 18.00	<b>Stefan Vigerske (Humboldt University Berlin)</b> <i>Decomposition of multistage stochastic programs with recombining scenario trees</i>
18.00 - 18.25	<b>Michal Kaut (Molde University College)</b> <i>Solution methods for a multi-item newsvendor model with substitution</i>
19.30	Workshop dinner at Blonde, 75 St Leonard's Street, Edinburgh

#### Friday 5 September

09.00 - 10.00	Plenary talk: <b>Giorgio Consigli (University of Bergamo)</b> <i>SP-based dynamic optimization of a corporate portfolio subject to credit risk</i>
10.00 - 10.30	Coffee/Tea
	Contributed talks session - Applications
10.30 - 10.55	<b>Francesca Maggioni (Università degli studi di Bergamo)</b> <i>Stochastic second-order cone programming in mobile ad-hoc networks</i>
10.55 - 11.20	<b>Nicole Nowak (Technische Universität Darmstadt)</b> <i>Production chains: An application from mechanical engineering</i>
11.20 - 11.45	<b>Eva Zampachova (Brno University of Technology)</b> <i>Solution of selected engineering problem modeled by PDE constrained stochastic program</i>
11.45 - 12.10	<b>Yu Yu (University of Edinburgh)</b> <i>Stochastic ship fleet routing with inventory limits</i>
12.10 - 12.35	<b>Natalia Issaeva (University of Edinburgh)</b> <i>Stochastic programming for a problem of incorporation of wind energy to the electricity generation system</i>
12.35 - 13.45	Lunch
13.45 - 14.45	Plenary talk: <b>Alexander McNeil (Heriot-Watt University)</b> <i>Financial risk and capital allocation</i>
14.45 - 15.15	Coffee/Tea
	Contributed talks session - Finance and Algorithm
15.15 - 15.40	<b>Xi Yang (University of Edinburgh)</b> <i>Portfolio selection models with stochastic dominance constraints solved by OOPS</i>
15.40 -	<b>Alex Weissensteiner (University of Innsbruck)</b>

16.05	<i>ALM models and the absence of arbitrage</i>
16.05 - 16.30	<b>Mohammad Reza Peyghami (KN Toosi University of Technology)</b> <i>An interior point approach for semidefinite optimization</i>
16.30 - 16.55	<b>Andreas Grothey (University of Edinburgh)</b> <i>Interior point warmstarts applied to stochastic programming</i>
16.55 - 17.05	Concluding remarks



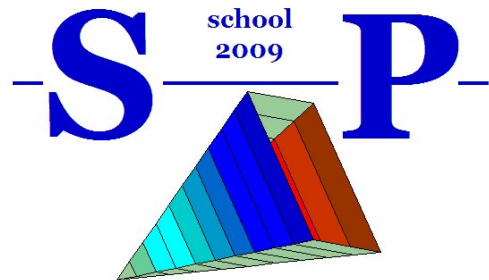
## APPENDICE C. La scuola di ottimizzazione del 2009



cariplo  
**STOCHASTIC PROGRAMMING SCHOOL**

[www.unibg.it/SPS2009](http://www.unibg.it/SPS2009)  
[sps2009@unibg.it](mailto:sps2009@unibg.it)  
==> [e-learning](#)

**UNIVERSITY of BERGAMO**  
**23 - 28 November 2009**



**stochastic programming:  
theory and applications**



**UNIVERSITÀ  
DEGLI STUDI  
DI BERGAMO**  
[www.unibg.it/dmsia](http://www.unibg.it/dmsia)

### 1. Project Topic and Objectives

The University of Bergamo is pleased to announce an intense week of training, to take place between November 23 and November 28, 2009, as final event of the three year advanced training program funded by the Cariplo Foundation, dedicated to Stochastic Programming Techniques for decision support systems. The **The SPS2009 – Stochastic Programming School 2009** initiative is oriented to researchers, doctoral students and practitioners with a general aim to attract a significant audience to a key and rapidly growing area of mathematical programming.

The school aims also at establishing a qualified venue to enhance and promote the understanding by young scientists of the potentials of applied stochastic optimisation in different application areas such as finance, energy, telecommunications and clarify to leading practitioners the current state of the art in the development of stochastic optimisation techniques. In August 2010, Dalhousie University will host the XII Stochastic programming Symposium and SPS2009 represents an ideal preliminary event to the International symposium, providing a qualified venue to young researchers and practitioners interested in stochastic programming theory and applications.

## 2. SPT4DSS *Cariplo* Advanced Training Project

The event follows the 2007 school in Bergamo and the 2008 workshop on Numerical Linear and Nonlinear Stochastic Programming organised by the University of Edinburgh. The *Cariplo* project funds training exchanges and initiatives jointly organised by the Department of Mathematics, Statistics, Computing and Applications (DMSIA) of the University of Bergamo, and leading Departments of four European Universities coordinated by well-recognised scholars working in the area of stochastic optimization:

- Professor **Georg Pflug**, Head of Department of Statistics and Decision Support Systems (DSDSS) of the University of Vienna (AU)
- Professor **Gautam Mitra**, Director of the Centre of applied research CARISMA of the University of West London Brunel (UK)
- Professor **Jacek Gondzio** of the School of Mathematics at the University of Edinburgh (SMED, UK)
- Professor **Alexei Gaivoronski** of the Department of Industrial Economics and Technology management, Norwegian University of Technology (NTNU), Trondheim in Norway.

SPS2009 represents the concluding event of the 3-year project that through dedicated scholarships has funded event registration, travelling and accommodation expenses for roughly 30 students per year over the triennium mainly European students of the five Universities in the Network but also coming from extra-European countries (China, Brazil, United States, Canada, Turkey, Russia).

## 3. School Program

The programme combines theory and applications in finance, energy, ITC, and other application areas where dedicated developments did recently took place in the industry. Theoretical lectures are essentially proposed in the morning and the afternoons are left to computer labs for a practical adoption of SP techniques and young researchers presentations.

The school has been structured to cover topics in the following areas:

- Stochastic optimization, introduction and key results
- Scenario generation and approximation of stochastic processes
- Integer, mixed integer, chance constrained, non standard linear and non linear stochastic programming
- Model generation and solution methods for different problem classes

The program is delivered over five days plus one morning, each day specifically organised by one Partner of the *Cariplo SPT4DSS* network.

A special issue of the Journal *Statistics & Decisions* will be published including selected articles from the Young researchers contributions and the state-of-the-art talks presented in the concluding session of the school.

### 3.1 Computer Sessions

Over the SPS2009 week, every afternoon a set of computer lab sessions is organised to develop a case-study from a problem mathematical formulation to its numerical solution relying on commercially available as well as dedicated software developments. The initiative aims at training hands on the school attendants over the key elements of a stochastic programming developments. The organising partners will cooperate to share part of their in-house developments. At the end of the week the school attendants will be allowed to download the programs developed during the week plus dedicated software modules made available by the organising committee.

### 3.2 Young Researchers Contributions

The School will leave space every afternoon to theoretical and applied contributions (three per day, for a total of 15 talks over the entire program) by young researchers and practitioners attending the school in the general domain of *Decision making under uncertainty* related to:

- Mathematical programming and dynamic optimisation in particular
- Two-stage and multistage stochastic programming
- Sampling techniques for large scale problems
- Model generation and software developments
- Solution techniques for linear and nonlinear programmes
- Output analysis for large-scale decision problems.

Submitted papers, in the spirit of the school, can be theoretical or, preferably, addressing decision and valuation problems in application areas such as economics and finance, energy, telecommunications, industry, etc.

Unpublished articles or extended abstracts may be submitted before August 31, 2009 (article submission deadline) to [sps2009@unibg.it](mailto:sps2009@unibg.it), following the scheme in the [web page](#). The submissions will be handled on a first-in basis, up to program completion. Accepted papers will be included in the programme by subject, following the school evolution. Talks are expected to last 40 minutes to leave 5 minutes for comment and discussion.

### 3.3 Schedule

The school, November 23—November 28, 2009, is based daily on two morning lectures followed by a technical session in the computer LAB, and three 40-minute talks starting at 3:15 pm. The concluding day will be dedicated to presentations on selected topics providing the state-of-the-art and open problems presented by scholars of the five Departments in the Network.

DAY 1 (University of Bergamo): Methods and applications in dynamic stochastic programming

Lecturer: Giorgio Consigli

Morning session (9:30—12:30): *Fundamental results of multistage stochastic programming (MSP), the key properties of MSP viz-a-viz stochastic control and dynamic programming formulations are considered and a range of application fields presented and discussed in this opening session. Key mathematical assumptions and modelling issues supporting the adoption of SP techniques are considered with respect to different application areas, with an emphasis on modelling and methodological cross-over to be fully considered in order to maximise the practical adoption of stochastic programming methods.*

12:30—13:30 Lunch Break

14:00-15:15 COMPUTER LAB 1

*Mathematical formulation and implementation of a simple ALM problem with the GAMS algebraic language.*

15:30-17:30 PM: **YOUNG RESEARCHERS PRESENTATIONS**

TALK 1: R.Riccardi and R.Toninelli: Stochastic Data Envelopment Analysis with scenarios generation technique

TALK 2: D.Wozabal and G.Pflug: A multi-stage stochastic programming model for managing risk-optimal electricity portfolio

TALK 3: K. Emich, H.Heitsch, A. Moller, W. Romisch: Airline network revenue management under uncertainty by Lagrangian relaxation

TALK 4: R.Riemke, F. Oliveira and S.Hamacher: The development of a stochastic optimization model for the biodiesel supply chain based on small farmers

Day 2 (CARISMA Centre, Brunel University of West-London): Mathematical specification and model generation for stochastic programmes

Lecturer: Diana Roman

Morning session (9:30—12:30): *The extension of the stochastic program formulation leading to mixed and integer programs and the generalization of the objective function including alternative formulations of the mathematical program leading to stochastic quadratic programs are discussed in this section. The integration of advanced simulation techniques, scenario generation methods and efficient solution algorithms are presented focusing on the required validation through Monte Carlo of financial scenario generation and optimal policy implementation.*

12:30—13:30 Lunch Break

14:00-15:15 COMPUTER LAB 2

*The AMPL algebraic definition and model generation for stochastic programs with alternative formulations.*

15:30-17:30 PM: **YOUNG RESEARCHERS PRESENTATIONS**

TALK 1: B. Flach: Stochastic Programming with Endogenous Uncertainty: an



Application in Humanitarian Logistics

TALK 2: A.M.Pedersen, K.M.Rasmussen, H.Vladimirou, J.Klausen: Integrated Mortgage Loan and Pension Planning

TALK 3: B.Fortz, M.Labbe, F.Louveaux and M.Poss: The Knapsack Problem With Gaussian Weights

TALK 4: A.Pichler and G.Pflug: Quantization by unit cubes in high dimensions

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DAY 3 (University of Vienna): Approximation of stochastic programmes and financial applications

Lecturer: Georg Pflug

Morning session (9:30—12:30): *The formulation of multistage stochastic programming problems leads to a relevant trade-off between accurate representation of the underlying source of uncertainty characterising the decision problem and its numerical tractability. A range of approximation results and their actual implementation in financial planning problems are presented in this session, linking recent theoretical advances on probability measures convergence in appropriate functional spaces to critical modelling choices in real-world cases.*

14:00-15:15 COMPUTER LAB 2

*Monte Carlo simulation and scenario generation for the ALM problem.*

15:30-17:30 PM: **YOUNG RESEARCHERS PRESENTATIONS**

TALK 1: C.Vincent, L.L. Hay, C.E. Peng: A Distribution problem of Chance-Constrained Fractional Programming with General form of Distributions

TALK 2: M. Branda: Reformulation of general chance constrained problems using penalty functions

TALK 3: T.Sinotina: Universal confidence sets for the mode of regression function

TALK 4:

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DAY 4 (NTNU): STOCHASTIC PROGRAMMING APPLICATIONS IN ENERGY AND ITC

Lecturer: Asgeir Tomasgard

Morning session (9:30—12:30): *Stochastic programming formulations are increasingly adopted for decision problems arising in energy and information technology applications. In liberalised energy markets the first application domain is increasingly incorporating the technology developed for the formulation and solution of decision problems affected by market uncertainty. Stochastic programming has been recently adopted to address both equilibrium problems in the energy industry and optimal management problems in presence of non-storable outputs. On the other hand ITC applications call for the adoption of network-based stochastic optimisation techniques and problem formulations that have a similar nature. In this session the modelling and solution issues in these two application areas are presented and discussed in detail.*

14:00-15:15 COMPUTER LAB 3

*Deterministic equivalent derivation and model generation. Solution analysis for the SLP problem*

**15:30-17:30 PM: YOUNG RESEARCHERS PRESENTATIONS**

TALK 1: J Blevins: Approximation Algorithms for Stochastic Quasi-Gradients: Sum and Max Rules

TALK 2: G.Ribas, A. Leiras and S.Hamacher : Operational planning under uncertainty of an oil refinery

TALK 3: R.Riccardi: Hierarchical Fleet Mix Problems with risk-aversion: a CVaR approach.

TALK 4: L.C. da Costa Jr: Considering Reliability Constraints in the Power Systems Expansion Planning Problem

**DAY 5 (UNIVERSITY OF EDINBURGH): NUMERICAL METHODS FOR THE SOLUTION OF LARGE-SCALE STOCHASTIC PROGRAMS**

Lecturer: Jacek Gondzio

Morning session (9:30—12:30): *The solution of multistage stochastic programs whose structural properties and dimension is recognised to depend on the problem initial formulation (in terms of stages and set of variables and equations) and the number of scenarios calls for the adoption of efficient algorithms explicitly dealing with the possible curse of dimensionality and exploiting the block-diagonal structure of the coefficient matrix. In this session the adoption of Interior point methods for the solution of large-scale stochastic programs and the nonlinearities induced by a set of possible specifications of risk-return objectives are presented and discussed in detail for a class of financial planning problems.*

12:30—13:30 Lunch Break

14:00-15:15 COMPUTER LAB 4

*Solution of the ALM problem as SLP and SQP problems. Additional constraints. Solution analysis. Test problems delivery.*

**15:30-17:30 PM: YOUNG RESEARCHERS PRESENTATIONS**

TALK 1: J Hubner and M.Steinbach: A Parallel Code Generator for Multistage Stochastic Programs

TALK 2: N. Chiang : Solving Security Constrained Optimal Power Flow Problems by a Structure Exploiting Interior Point Methods

TALK 3: F.S.Thomè : Decomposition technique with implicit multipliers evaluation in electrical expansion planning

**DAY 6 -- NOVEMBER 28: STATE-OF-THE-ART**

*On the last day of the school, the partners of the SPT4DSS network present the state-of-the-art*

*developments and key results to share with the school attendants the current standards in applied stochastic programming and the open problems. Five 30 minutes talks are presented starting at 9:30.*

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**13:00 SPS2009 CLOSURE**

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#### 4. Registration

**The deadline for regular registration is September 30, 2009.**

<b>FEES IN EURO</b>		
	Academics	Practitioners
full program	250	400
individual days	80	150

Table 1. Registration fees until September 30, 2009

**Late registrations** to the full program will be accepted from October 1 until November 17, 2009 with the following costs:

<b>FEES IN EURO</b>		
	Academics	Practitioners
full program	300	500
individual days	100	200

Table 2. Late registration fees (after October 1, 2009)

Registration fees will cover the school material (including the case problems and codes developed during the lab sessions), lunches, and the conference dinner (November 27, 2009). All applicants are expected to cover the costs of their journeys and the evening meals. **REGISTER NOW!**

Registered students can apply to the Organising committee to have accommodation costs covered by a scholarship. A number of 25 **Cariplo sponsorships** of 400 Euros each will be provided by the committee: the sponsorship can cover (up to the occurrence of 400 Euros) the registration fee, travelling, accommodation and living costs. Specifically: registration fees and travelling expenses will be refunded upon submission of the related costs incurred by the school attendants, while the accommodation and living costs will be directly funded by the Organisers. Early registered students with accepted presentations included in the programme will be given priority in the sponsorship assignment. Applicants will be considered on a first-in basis. **APPLY NOW!**

The following average costs per day per person (excluding travel costs to reach Bergamo) have

been estimated to attend the school and are here reported to help Italian and foreign applicants in their financial planning:

- Accommodation: in nearby B&B's and hotel, according to the accommodation list in the web page, from 50 euro
- Evening meal: from 10 to 25 euro
- Daily costs outside the school (transport to reach the school, drinks and breaks): 5 to 10 euro.

## 5. Organisation and Management

The **Organising Committee** is based in Bergamo (Italy) and formed by:

Giorgio Consigli - [giorgio.consigli@unibg.it](mailto:giorgio.consigli@unibg.it)

Vittorio Moriggia - [vittorio.moriggia@unibg.it](mailto:vittorio.moriggia@unibg.it)

Francesca Maggioni - [francesca.maggioni@unibg.it](mailto:francesca.maggioni@unibg.it)

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The programme has been structured in cooperation with the **training partners**:

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Gautam Mitra (CARISMA, Brunel West-London University, UK)

Alexei Gaivoronski (NTNU)

Jacek Gondzio (SDMED, University of Edinburgh)

## 6. Sponsorships

The school is sponsored by the **Cariplo Foundation**



and endorsed by



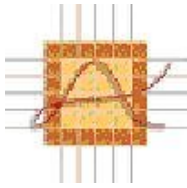
**University of Bergamo**

[www.unibg.it](http://www.unibg.it)



**The Stochastic Programming Community**

[www.stoprog.org](http://www.stoprog.org)



**The Italian Association of  
Mathematics Applied to Economic and Social Sciences**

[www.amases.it](http://www.amases.it)



**The Italian Association of  
Operations Research**

[www.airo2.org](http://www.airo2.org)



**Italian Federation of Applied Mathematics**

[www.fimaonline.it](http://www.fimaonline.it)

## **7. Location and Infrastructure**

The Faculty of Economics of the University of Bergamo – [www.unibg.it/economia](http://www.unibg.it/economia) – provides an ideal environment for the school. A modern building realised roughly 10 years ago with fully computerised classrooms and a conference room. Depending on the attendance we can easily accommodate from 50 to 150 students during the proposed period. Lunch breaks will be organised by the faculty mensa in the same location.

A number of hotel and B&B accommodations are also available in the neighbourhood of the school location at agreed rate.

## **8. Added Value of Participants**

Stochastic programming is almost by definition a field at the conjunction of optimisation theory, stochastic processes and probability theory and decision theory under uncertainty. Participants will gain insight in different application areas and at the same time be confronted with the challenges coming from the industry and the theoretical results of stochastic optimisation theory with implications on valuation theory, dynamic decision making and economic and financial planning.

We also aim with this initiative to strengthen and enlarge the area of young researchers interested in the subject of stochastic optimisation, that we see at the heart of future scientific development from a computational and optimisation viewpoint.

## APPENDICE D – Pubblicazioni

### D.1 Il volume di ottimizzazione stocastica di SPRINGER

*International Series  
in Operations Research & Management Science*

Frederick S. Hillier, Series Editor  
Camille C. Price, Special Editorial Consultant

STOCHASTIC OPTIMIZATION METHODS IN FINANCE AND ENERGY  
New financial products and strategies in liberalised energy markets

Expected Summer 2010

EDITORS: M. I. BERTOCCHI<sup>\*</sup>; G. CONSIGLI<sup>\*</sup>; M.A.H. DEMPSTER<sup>†</sup>

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#### Features

- First collection of real-world case studies formulated and solved as multistage stochastic programs in both the energy and financial sectors
- Extended analysis of new financial products and related dynamic optimization problems for institutional investors such as pension funds and insurance companies
- Overview of optimization and equilibrium models in liberalized energy markets
- Integrated view of common methodological and economic aspects of applied problems arising in competitive financial and energy markets
- Description of implemented decision support systems in the financial and energy sectors
- Contributors are internationally recognized scholars and leading practitioners in the financial and energy communities
- New theoretical results strictly connected with the presented case studies

Preface – M.I. Bertocchi, G. Consigli and M.A.H. Dempster

#### PART I. Financial Applications

- 1) MacLean L.M. and W.T.Ziemba: *A general Kelly strategy for investing*

- 2) **Mulvey J., W.Chang Kim and Yi Ma: *Achieving global diversification of equities via a multi-stage stochastic program***
- 3) **Vladimirou H. and N.Topologlou. *Market and currency risk hedging with options & forwards in portfolio management problems***
- 4) **Consigli G., G.Iaquinta, V.Moriggia, P.Beraldi, A.Violi, F.De Simone: *Hedging credit and market risk in corporate portfolio management***
- 5) **Dempster M.A.H., M. Germano, E.A. Medova, J. K. Murphy, D. Ryan and F. Sandrini: *Risk profiling for defined benefit pension schemes using dynamic stochastic programming***
- 6) **Consiglio A. and D. De Giovanni: *A stochastic programming approach to price embedded options in insurance contracts***
- 7) **Barro D. and E. Canestrelli: *Optimal portfolio structuring for index linked products***

## **PART II. Energy Applications**

- 8) **Ramos A.: *Decision support model for weekly operation of hydrothermal systems by stochastic nonlinear optimization***
- 9) **Vespucci M.T., F.Maggioni, M.Bertocchi, E.Allevi and M.Innorta: *Short-term stochastic resource scheduling models for an electricity producer in a liberalized electric energy market***
- 10) **Conejo A., L.Garces and C.Triki: *Short-term trading for electricity producers***
- 11) **Alonso-Ayuso A., N. di Domenica, L.F.Escudero and C.Pizarro: *On modeling the structuring of energy contract portfolios in competitive markets***
- 12) **Tomasgard A. and F.Marte: *Tactical portfolio optimization and contract management in the natural gas supply chain***
- 13) **Römisch W. and A.Eichorn: *Electricity risk management in liberalized energy markets***
- 14) **Drapkin D., R.Gollmer, U.Gotzes and R. Schultz: *Risk management with stochastic dominance models in energy systems with dispersed generation***
- 15) **Ehrenmann A. and Y.Smeers: *Capacity expansion with risk adjusted discount rates in competitive electricity markets***

## **PART III. Theoretical Issues Computation and Solution Methods**

- 16) **Römisch W. and H.Heitsch:** *Scenario tree generation for multi-stage stochastic programs*
- 17) **Pflug G. and A.Pichler:** *Scenario generation from an algorithmic perspective*
- 18) **Dempster M.A.H., E. A. Medova and Y.S.Yong:** *Scenario generation for dynamic stochastic programming*
- 19) **Henrion R. and C.Strugarek:** *Convexity of chance constraints with dependent random variables: The use of copulas*
- 20) **M. Steinbach:** *Algorithmic approaches to nonlinear multistage stochastic programs*

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## Overview

The volume presents a collection of contributions dedicated to applied problems in the financial and energy sectors that have been formulated and solved in a stochastic optimization framework. The invited authors represent a group of scientists and practitioners, who cooperated in recent years to facilitate the growing penetration of stochastic programming techniques in real-world applications, inducing a significant advance over a large spectrum of complex decision problems.

After the recent widespread liberalization of the energy sector in Europe and the unprecedented growth of energy prices in international commodity markets, we have witnessed a significant convergence of strategic decision problems in the energy and financial sectors. This has often resulted in common open issues and has induced a remarkable effort by the industrial and scientific communities to facilitate the adoption of advanced analytical and decision tools. The main concerns of the financial community over the last decade have suddenly penetrated the energy sector inducing a remarkable scientific and practical effort to address previously unforeseeable management problems. This proposal aims to include in a unified framework for the first time an extensive set of contributions related to real-world applied problems in finance and energy, leading to a common methodological approach and in many cases having similar underlying economic and financial implications.

During the spring and the summer of 2007 the School of Stochastic Programming held in Bergamo ([www.unibg.it/sps2007](http://www.unibg.it/sps2007)), and the eleventh symposium on Stochastic Programming in Vienna (<http://www.univie.ac.at/spxi>), offered two venues for the presentation of the chapters included in the volume. After the two events, during the fall of 2007, all the invited contributors enthusiastically accepted the invitation to present their original work in the projected volume, from which this proposal was developed.

The volume is structured in three parts, devoted to contributions related to financial applications – Part I, with 7 chapters; energy applications – Part II, with 8 chapters; and to specific



theoretical and computational issues – Part III, with 6 chapters -- recently developed in the scientific community and explicitly related to the applied problems presented.

The chapters in Parts I and II, all address modelling and implementation issues arising in multistage stochastic programming formulations, and focus on real world problems in finance and energy, so that common solutions and open problems are clearly identified. In each part the individual chapters are ordered moving from the general to the specific, across topics proposed in a logical and connected order. The way forward in applied stochastic optimization is in this way indicated.

In chapter 1, the classical problem of capital accumulation under uncertainty, that has occupied over the years a central role in the theory of economics and finance, is revisited by MacLean and Ziemba to analyze the actual performance of portfolio management schemes relying on so-called *Kelly* or *capital growth strategies*, whose long run asymptotic properties lead to the definition of optimal strategies for “sufficiently patient” investors. The optimality of the Kelly strategy is related to expected values, either of log wealth or first passage times. In presence of probabilistic security constraints the problem of maximizing the rate of growth of wealth leads to a nonconvex optimization problem, difficult to solve. The authors after reviewing the key theoretical results leading to the adoption of complete or partial Kelly strategies, present an alternative solution approach based on the introduction of a convex penalty on violations of drawdown conditions and analyze the comparative performance of the different modeling approaches for a long-term equity investor.

Chapter 2 by Mulvey *at al* generalizes the above analysis to consider the problem of large investors managing optimally their international equity portfolios but taking into account industrial diversification. By tradition, diversification of equity markets requires subdividing the population of stocks according to three factors: 1) company size (large, medium, small), 2) style (value versus growth) and 3) geographical location (country or region). These asset categories have become less distinctive over the recent past due to the growth of global enterprises, changing market conditions, and the flexibility of company executives in modifying their capital structure. In response, the authors suggest that optimal asset allocation ought to be accomplished by diversification across a relatively large set of industrial categories (35 to 70). A stochastic program provides the ideal setup for constructing a dynamic optimal investment portfolio with industrial diversification. Several illustrative examples are presented in the chapter.

The subsequent two chapters develop further the analysis of widely adopted risk-reward paradigms in two different settings: under exposure to exchange rate fluctuations (Vladimirou and Topaloglu), to correlated interest and default risk (Consigli *et al*)

Vladimirou and Topaloglu address in chapter 3 the problem of optimal risk management of international portfolios exposed to market and currency risk in a multistage framework. The inclusion in this case of derivative contracts such as options and forwards provide an important generalization of previously adopted modeling approaches, leading to a complex pricing problem in an incomplete capital market (further explored by Consiglio in chapter 6). Consigli *at al* consider instead in chapter 4 the problem of managing dynamically in an integrated fashion a real portfolio in this case exposed to interest rate and default risk. No derivative contracts are in this case considered, but rather the potential of a stochastic programming formulation for indirect hedging is tested on a large-scale corporate portfolio. The potentials of a GRID

architecture resulting in a computationally efficient framework are also discussed and the modular structure of the resulting decision support system analyzed in this context.

The relationship between stochastic optimization methods and three different financial engineering applications is analyzed in the chapters 5, 6 and 7 by Dempster *et al*, Consiglio, and Barro and Canestrelli, respectively. All three contributions analyse from different perspectives the analytical and financial implications of portfolios optimal replication strategies in presence of target payoffs, such as those arising in optimal tracking problems in the fund management industry and hedging problems in option markets over arbitrary time horizons.

In chapter 5 Dempster *et al* present a dynamic model for a pension fund with a minimum guarantee constraint, able to generate an efficient financial strategy under the specific underfunding risk. Recent changes to the accounting reporting standards for final salary or defined benefit (DB) schemes in the UK, US, the Netherlands and elsewhere, combined with low real bond yields have indeed led to a situation in which many companies have being forced to pay more attention to their pension schemes. Schemes that seemed in healthy state are suddenly found to be under-funded and regulatory changes are forcing sponsors to address the deficit immediately.

Optimal portfolio management by pension funds with minimum guarantees combine the optimal tracking and the option valuation problems in a unique, often complex, mathematical framework. In a discrete time, discrete state model such as the one considered by stochastic programming formulations the optimal replication problem of a given payoff translates into an option valuation problem in incomplete markets. This problem is analysed by Consiglio in chapter 6 in particular for the case of an insurance contract.

Life insurance products are in fact usually equipped with minimum guarantee and bonus provision options. The pricing of such claims is vital for the insurance industry. Risk management, strategic asset allocation, and product design depend on the correct evaluation of these contingent claims. To overcome Black & Scholes limitations, the author has developed a stochastic programming model to determine the fair price of the minimum guarantee and bonus provision options. An extensive empirical analysis is presented to highlight the effect of incompleteness on the fair value of the option, and show how the whole framework can be used as a valuable normative tool for insurance companies and regulators.

The last chapter of part I, presents a decision problem again related to the optimal replication in a dynamic framework of index-linked products. Barro and Canestrelli consider the problem of optimal portfolio structuring and management for a fund connected with index linked products. Again a dynamic portfolio optimization scheme is proposed to include in a real application different goals and liabilities related to the structure of a complex payoff function with a minimum guaranteed return.

The seven chapters of part I move from a classical financial management problem to a large set of state-of-the-art applications in finance within a dynamic stochastic programming paradigm. The key issues of a stochastic programming mathematical formulation, scenario generation for a wide set of financial management problems, risk characterization and optimal portfolio control are all considered. From the small (chapter 1) to the big (chapters 2, 3, 4 and 5), individual and Institutional investors, such as Pension funds and Insurance companies, financial management problems are presented in different applied case-studies providing an extremely rich set of evidences and practical suggestions to both the academia and the industry.

Many of the methodological issues addressed in part I of the volume, return in the chapters dedicated to energy applications. The advent of liberalized energy markets has brought about an increasing need for new modeling approaches and efficient risk management tools, strengthening the cooperation between the scientific community and the industry as shown in the case-problems analyzed in this second part. The growing environmental concerns related to the energy sector development worldwide have also pushed for the adoption of new and more efficient decision support systems taking into consideration the implications and economic sustainability of alternative energy policies, resulting in additional constraints in the optimization framework. Unlike financial applications, where securities are held over time and investors intertemporal strategies rely explicitly on inventory balance constraints linking period to period, optimal policies by energy producers, confronting significant market risks, are often to be determined taking into account the physical nature of non-storable energy. In competitive markets with a limited number of energy suppliers and state controlled network connections, furthermore, energy producers must identify optimal supply policies taking into account the competitors' behavior. These aspects add complexity to the definition and solution of stochastic optimization problems in the energy sector and are fully reflected in the chapters of this second part.

In chapter 8, Ramos formulates and solves an optimal resource allocation problem of thermal and hydro power plants with multiple basins and multiple connected reservoirs. The stochastic factors of the problem are here represented by natural hydro inflows. A multivariate scenario tree is in this case obtained taking into account the stochastic inputs and their spatial and temporal dependencies. The hydro power plant efficiency depends on water head and reservoir volume depends nonlinearly on water head, leading to a large-scale stochastic nonlinear optimization problem, whose formulation and solution are detailed by the author.

In the following chapter 9 Vespucci *et al* analyze an optimal short-term hydro-thermal coordination problem for the case of a small price-taker producer seeking the maximization of the expected profits. Day-ahead market prices and reservoirs inflows are characterized by uncertainty caused by market fluctuations and unpredictable weather conditions. A multi-stage stochastic program framework is appropriate, as information evolves over time and uncertainty may be disclosed in stages. The overall objective of the stochastic program is to establish a one-day production plan in order to find a trade-off between current profits and expected future profits, subject to operational constraints. In the subsequent chapter 10 Triki and Conejo consider the problem of optimally bidding in the spot electricity markets by each power producer with the aim of maximizing his profits. The multiplicity of bidding opportunities (auctions) and the limitations imposed by technical constraints and market rules make the problem difficult to model and solve. Further difficulties are represented by the dynamic and stochastic natures that characterize the decision process. The authors focus on the use of stochastic programming to deal with the bidding problem and survey the different modeling paradigms for its formulation and the existing solution methods used for its solution.

In chapter 11 Alonso-Ayuso *et al* propose for a similar problem a multi-stage mixed integer full recourse model for structuring energy contract portfolios in competitive markets again for price taker agents. The main uncertain parameters are represented by spot energy prices, water exogenous inflows to the hydro system and fuel and gas costs and availability. The objective function is given by the maximization of the expected bilateral and spot market trading profit along the time horizon over the scenarios. The problem is formulated as a mixed 0—1

deterministic equivalent model. Only 0--1 variables have nonzero coefficients in the first-stage constraint system. All continuous variables only show up in the formulation of later stages.

In chapter 12 Tomasgard and Marte introduce a comprehensive network model to solve a tactical (up to 3 years) planning problem in the natural gas supply chain of a Norwegian producer. The authors present a decision support tool for a large producer with a portfolio of production fields and access to the transportation grid. The system takes a global view of the supply chain, including elements as production fields, transportation pipelines, storages, bilateral contracts and spot markets. The need for a stochastic optimization framework is in this case due to the inclusion of bilateral contracts in which the buyer's nomination and the prices are treated as uncertain parameters. Spot energy prices are also uncertain. The goal for the producer is to allocate the equity gas and use the market flexibility so that delivery obligations and expected profit maximization are both attained. The authors address in an integrated way the short-term expected profit maximization problem under the long-term transportation bottlenecks and other infra-structural constraints.

Under conditions of increasing commodity price volatility the need to address in a coherent financial framework an efficient hedging strategy is considered and leads to the following two chapters, 13 and 14, by Römisch and Eichorn, and Drapkin *et al* respectively, specifically devoted to two possible dynamic formulations of the risk management problem in liberalized energy markets.

In the first contribution Römisch and Eichorn present a stochastic optimization model dealing with the electricity risk management problem and analyze alternative real-world scenarios for energy prices and demand to be confronted by a set of competing energy producers. Drapkin *et al* do instead propose a new approach to risk management in energy optimization employing the concept of stochastic dominance. This leads to a new class of large-scale block-structured mixed-integer linear programs for which the two authors present a decomposition algorithm involving Lagrangean relaxation and cutting plane techniques. The new methodology is applied to stochastic optimization problems related to operation and investment planning in energy systems with dispersed generation.

In the final chapter of Part II, Ehrenmann and Smeers analyze in a long term perspective probably one of the oldest applications of optimization, such as the capacity expansion model, whose solution needs to be reconsidered after the profound industry restructuring observed in recent years and the mentioned energy prices liberalization. The authors analyse the implications of optimal investment strategies within an equilibrium model with risk-averse agents. A new model paradigm is presented taking fully into account the endogenous nature of the investment cost of capital. The behaviour of agents is described by a multistage risk function. We use a multistage version of Cochrane good deal to obtain a risk function that has good time consistency properties. This risk function allows one to tie in the formulation with standard models of corporate finance such as the CAPM and the APT. The problem is formulated as a stochastic complementarity problem. It has so far been impossible to prove any monotonicity property of the model but more general fixed-point theorems can be invoked to prove existence of equilibrium. Ehrenmann and Smeers contribution links appropriately the second part with the following chapters dedicated to a limited set of theoretical and computational issues.

The eight chapters of part II provide a unique and well-integrated set of contributions addressing valuation and decision problems in the energy sector after the recent policy changes.

It is clear the parallelism between short-term optimal dynamic portfolio policies in financial markets and optimal management of electricity contracts under energy price volatility. In both cases, from a methodological viewpoint, the need to combine an accurate model of uncertainty with a decision tool leading to an efficient decision process clarifies the similar requirements of the related decision models. In the second part of the volume we move from the tactical to the strategic horizon, with increasingly relevant policy implications. Several case studies in parts I and II, call for efficient approximation methods of generally underlying continuous probability distributions associated with the stochastic nature of the decision problems and at the same time effective solution schemes for typically computationally intensive programs.

In Part III of the book we consider six recent theoretical developments explicitly addressing the issues of scenario tree generation and the numerical implications associated with the solution of linear and nonlinear stochastic programs. In the first chapter of this third part Römisch and Heitsch present an overview of recent developments on scenario generation techniques for financial and energy problems, and analyze a set of theoretical results related to the approximation of random processes in appropriate functional spaces. Pflug and Hochreiter, taking a more practical view, follow up in chapter 17 to consider the numerical and algorithmic implications of the different approximation techniques.

In chapter 18 Dempster, Medova and Yong, focusing on multistage stochastic programs focus on theoretical and methodological issues arising in real world applications from the formulation of a statistical model describing the key relationships between the random factors of the problem and its practical validation. The relationship between model choice and planning horizon of the associated stochastic program is also considered by the authors.

The three chapters jointly provide an accurate assessment of the procedures adopted in the case studies presented in parts I and II.

The stability properties of stochastic programming solutions are considered in chapter 19 by Dupačova, while the convexity properties of stochastic optimization problems with chance constraints are discussed in chapter 20 by Henrion and Strugarek.

In her contribution Dupačova summarizes the debate on robust policies with respect to the results of stochastic programming applications, as a consequence of the misspecifications due to simplification, approximation and incomplete information, often introduced in the models. Robustness analysis focuses on quantification of the influence of out-of-sample scenarios, of additional stages or changes of scenario probabilities on the optimal solution. The problem of incomplete or imprecise knowledge of scenario probabilities may be approached by minimax or analyzed by suitable stability analysis methods. The author illustrates the existing and prospective applications of the minimax approach, of the methods of robust and asymptotic statistics and results of parametric programming.

Henrion and Strugarek do extend the classical theory of chance-constrained problems with independent random processes to the case of codependence modeled through copulas. The related theoretical results are presented and a number of examples discussed.

In the final chapter of the volume Steinbach presents a detailed overview of developments related to the complex solution of nonlinear and sometime non convex stochastic programs, which are becoming increasingly relevant in presence of risk averse decision makers and

derivative valuation problems in finance as well as combined optimization of production and trading of power problems in the energy sector. The chapter provides an overview of developments towards practical solution methods for nonlinear/non convex two-stage and multi-stage stochastic programs without integrality constraints. The author covers first some early approaches to two-stage stochastic programs, based on linear programming and cutting plane techniques. Then analyzes the implications of nonlinearity from an algorithmic viewpoint, addressing convergence issues as well as memory and runtime efficiency. The numerical performance of nonlinear solution methods is studied by Steinbach to underline their feasibility in practical optimization. Algorithmic approaches based on recent advances in large-scale nonlinear programming, with a focus on interior point methods and the efficient handling of KKT systems arising from large scenario tree models, are finally considered by the author.

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## D.2 Proceedings della scuola del 2009

A special issue of the *Journal Statistics & Decisions* will be published including selected articles from the young researchers contributions and the state-of-the-art talks presented in the concluding session of the school. The submission deadline is expiring at the end of April 2010 and as at today the following articles have been submitted:

- 1) P.Beraldi, G.Consigli, G.Iaquinta, F.De Simone and A.Violi: Optimal discrete-time strategies in a corporate market with jump-to-default processes
- 2) M.Branda: Reformulation of general chance-constrained problems using penalty functions
- 3) A.Grothey and X.Yang: Solving the top-percentile traffic routing problem by approximate dynamic programming
- 4) G. Iaquina, G.Consigli, M. Di Tria, V. Moriggia, and D.Musitelli: An asset-liability model for the optimal management of Insurance products
- 5) R.Kovacevic: Maximum-loss, minimum-win and the Esscher pricing principle
- 6) A.Leiras, G.Ribas and S.Hamacher: Operational planning of oil refineries under uncertainty
- 7) F.Oliveira, Raphael Leao and Silvio Hamacher: dealing with uncertainties in the Bio-diesel suppli chain based on small farmers
- 8) T.Sinotina and S.Vogel: Universal confidence sets for the mode of a regression function

The above papers will be regularly reviewed and published by the end of 2010 we expert.

GC 29/04/2010