

NUS-UTokyo Workshop on Quantitative Finance

26 – 27 September 2013

National University of Singapore

JOINTLY ORGANIZED BY:



Centre for Quantitative Finance
Faculty of Science



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PROGRAMME
Overview | Daily Schedule



Programme Overview

Thursday 26 September 2013	Friday 27 September 2013
08:30 – 08:50 Registration	08:30 – 09:00 Registration
08:50 – 09:00 Opening Address	
09:00 – 09:50 (IS) Eckhard PLATEN	09:00 – 09:50 (IS) Masaaki KIJIMA
09:50 – 10:20 Break	09:50 – 10:20 Break
10:20 – 11:10 (IS) Zhiliang YING	10:20 – 11:10 (IS) Huyen PHAM
11:10 – 12:00 (IS) Genshiro KITAGAWA	11:10 – 12:00 (IS) Takeaki KARIYA
12:00 – 14:00 Lunch	12:00 – 14:00 Lunch
14:00 – 14:50 (IS) Sira SUCHINTABANDID	14:00 – 14:50 (IS) Wanmo KANG
14:50 – 15:40 (IS) Cheng-Der FUH	14:50 – 15:40 (IS) Robert KIMMEL
15:40 – 16:00 Break	15:40 – 16:00 Break
16:00 – 16:20 (CS1A) Yao Tung HUANG (CS2A) Xianhua PENG	16:00 – 16:20 (CS1F) Takashi SHIBATA (CS2F) Kenichiro SHIRAYA
16:20 – 16:40 (CS1B) Ngoc-Minh DANG (CS2B) Ling FENG	16:20 – 16:40 (CS1G) Hideyuki TANAKA (CS2G) Ling TANG
16:40 – 17:00 (CS1C) Luis GONCALVES-PINTO (CS2C) Junko KOEDA	16:40 – 17:00 (CS1H) Tran Nguyen Ngoc Anh THU (CS2H) Yukihiro TSUZUKI
17:00 – 17:20 (CS1D) Yue LIU (CS2D) Marco MARCHIORO	17:00 – 17:20 (CS1I) HAILING WU (CS2I) Toshihiro YAMADA

Thursday 26 September 2013	Friday 27 September 2013
17:20 – 17:40 (CS1E) Keita OWARI (CS2E) Taiga SAITO	17:20 – 17:40 (CS1J) Yoshiro YAMAMURA (CS2J) Pingping ZENG
	17:40 – 17:50 Closing Address

Invited Talks
 Contributed Talks (Parallel Sessions CS1-CS2)

Lecture theatre is equipped with desktop computer connected to LCD projector, projector screen, visualizer, overhead projector, white board, and separate connection for personal notebook/laptop. Microphone will be provided.

Seminar rooms are similarly equipped except that visualizer and overhead projector are only available upon prior request. Microphone is not provided.

Thursday, 26 September 2013

TIME	ACTIVITY	VENUE	REF
08:30 – 08:50	Registration	LT 34 foyer	--
08:50 – 09:00	Opening Address	LT 34	--
Invited Talk			
09:00 – 09:50	Eckhard PLATEN University of Technology Sydney, Australia <i>The Affine Nature of Aggregate Wealth Dynamics</i>	LT 34	Pg5
09:50 – 10:20	Tea Break	LT 34 foyer	--
10:20 – 11:10	Zhiliang YING Columbia University, USA <i>Parameter Estimation Using Empirical Likelihood Combined with Market Information</i>	LT 34	Pg6
11:10 – 12:00	Genshiro KITAGAWA Research Organization of Information and Systems, Japan <i>Computational Issues Related to Sequential Monte Carlo Filter and Smoother</i>	LT 34	Pg4
12:00 – 14:00	Lunch	LT 34 foyer	--
14:00 – 14:50	Sira SUCHINTABANDID Chulalongkorn University, Thailand <i>Modeling Term Structure of Default Correlation</i>	LT 34	Pg6
14:50 – 15:40	Cheng-Der FUH National Central University, Taiwan <i>Reading between the Ratings: Modeling Residual Credit Risk and Yield Overlap</i>	LT 34	Pg1
15:40 – 16:00	Tea Break	LT 34 foyer	--
Parallel Session CS1A & CS2A			
16:00 – 16:20	Yao Tung HUANG Hong Kong University of Science and Technology, Hong Kong <i>Analysis of Optimal Dynamic Withdrawal Policies in Withdrawal Guarantees Products</i>	S17-04-04	Pg9
	Xianhua PENG Hong Kong University of Science and Technology, Hong Kong <i>Default Clustering and Valuation of Collateralized Debt Obligations</i>	S17-04-05	Pg12

Thursday, 26 September 2013

TIME	ACTIVITY	VENUE	REF
Parallel Session CS1B & CS2B			
16:20 – 16:40	Ngoc-Minh DANG John von Neumann Institute - Vietnam National University HCMC, Vietnam <i>Optimal Execution with Transient Impact</i>	S17-04-04	Pg7
	Ling FENG National University of Singapore, Singapore <i>From Empirical Behaviors to ARCH Modeling</i>	S17-04-05	Pg7
Parallel Session CS1C & CS2C			
16:40 – 17:00	Luis GONCALVES-PINTO National University of Singapore, Singapore <i>Long-Term Compensation and Managerial Choice of Effort and Risk</i>	S17-04-04	Pg8
	Junko KOEDA University of Tokyo, Japan <i>Endogenous Monetary Policy Shifts and the Term Structure: Evidence from Japanese Government Bond Yields</i>	S17-04-05	Pg9
Parallel Session CS1D & CS2D			
17:00 – 17:20	Yue LIU Nanyang Technological University, Singapore <i>Optimal Stopping for Selling a Derivative based on a Generalized Black-Scholes' Model with Regime-switching</i>	S17-04-04	Pg10
	Marco MARCHIORO University of Milan, Italy, and Quant Island, Singapore <i>Measuring Market Risk for VIX Futures Strategies</i>	S17-04-05	Pg10
Parallel Session CS1E & CS2E			
17:20 – 17:40	Keita OWARI The University of Tokyo, Japan <i>A Robust Version of Convex Integral Functionals</i>	S17-04-04	Pg11
	Taiga SAITO The University of Tokyo, Japan <i>Pricing Options with Absorption</i>	S17-04-05	Pg12

Friday, 27 September 2013

TIME	ACTIVITY	VENUE	PAGE
08:30 – 09:00	Registration	LT 34 foyer	--
Invited Talk			
09:00 – 09:50	Masaaki KIJIMA Graduate School of Social Science, Tokyo Metropolitan University, Japan <i>Credit-Equity Modeling Under a Latent Lévy Firm Process</i>	LT 34	Pg3
09:50 – 10:20	Tea Break	LT 34 foyer	--
10:20 – 11:10	Huyen PHAM University Paris Diderot (Paris 7), France <i>A Semi Markov Model for Market Microstructure and High-frequency Trading</i>	LT 34	Pg4
11:10 – 12:00	Takeaki KARIYA Graduate School of Global Business, Meiji University, Japan <i>Measuring Credit Risk of Individual Corporate Bonds and Deriving Term Structures of Default Probabilities</i>	LT 34	Pg2
12:00 – 14:00	Lunch	LT 34 foyer	--
14:00 – 14:50	Wanmo KANG Department of Mathematical Sciences, Korea Advanced Institute of Science and Technology, Republic of Korea <i>Design of Risk Weights</i>	LT 34	Pg1
14:50 – 15:40	Robert Kimmel National University of Singapore, Singapore <i>Statistical Inference Using Maximum-Correlation Portfolios</i>	LT 34	Pg3
15:40 – 16:00	Tea Break	LT 34 foyer	--
Parallel Session CS1F & CS2F			
16:00 – 16:20	Takashi SHIBATA Tokyo Metropolitan University, Japan <i>Investment Strategies under Debt Financing Constraints</i>	S17-04-04	Pg13
	Kenichiro SHIRAYA Mizuho-DL Financial Technology, Japan <i>Pricing Basket Options under Local Stochastic Volatility with Jumps</i>	S17-04-05	Pg13

Friday, 27 September 2013

TIME	ACTIVITY	VENUE	PAGE
Parallel Session CS1G & CS2G			
16:20 – 16:40	Hideyuki TANAKA Ritsumeikan University, Japan <i>Sparse Grid Techniques for Pricing Bermudan-style Options</i>	S17-04-04	Pg13
	Ling TANG National University of Singapore, Singapore <i>Calibration of Stochastic Volatility Models: A Tikhonov Regularization Approach</i>	S17-04-05	Pg14
Parallel Session CS1H & CS2H			
16:40 – 17:00	Tran Nguyen Ngoc Anh THU University of Finance and Marketing (UFM), Vietnam <i>Asymmetric Information and Investors' Options in Vietnam - Data Collected from the Ho Chi Minh City Securities Exchange</i>	S17-04-04	Pg14
	Yukihiro TSUZUKI The University of Tokyo, Japan <i>Pricing Bounds on Quanto Options</i>	S17-04-05	Pg15
Parallel Session CS1I & CS2I			
17:00 – 17:20	Hailing WU Nanyang Technological University, Singapore <i>Fredholm and PDE methods applied to Quadratic Functionals of the OU process</i>	S17-04-04	Pg15
	Toshihiro YAMADA The University of Tokyo, Japan <i>An Asymptotic Expansion for Forward-Backward SDEs</i>	S17-04-05	Pg16
Parallel Session CS1J & CS2J			
17:20 – 17:40	Yoshiro YAMAMURA Meiji University, Japan <i>Empirical Credit Risk Analysis on Euro Government Bonds</i>	S17-04-04	Pg16
	Pingping ZENG Hong Kong University of Science and Technology, Hong Kong <i>Pricing Bounds and Approximations for Discrete Arithmetic Asian Options under Time-changed Lévy Processes</i>	S17-04-05	Pg17
17:40 – 17:50	Closing Address	LT 34	--

ABSTRACTS
Invited Talks



**Reading between the Ratings:
Modeling Residual Credit Risk and Yield Overlap**
Cheng-Der FUH, Graduate Institute of Statistics, National Central University,
Taiwan

Credit ratings group firms by risk, yet yields are shown to overlap between firms of adjacent ratings. Therefore, we propose a model using Markov random walks to allow firms with the same rating differ in risk, but still keep the structure that a firm with better rating has lower default risk in general. We provide closed-form approximations for expected default time and tail probabilities, which is possible by applying results for Markov random walks and make use of the almost diagonal transition matrix of credit rating. Empirical fits for bond yield data are provided with robustness tests. Application to rating system evaluation is further proposed.

This is a joint work with Charles Chang and Michael Chu-Lan Kao.

Keywords: credit rating, yield curve, Markov model

Design of Risk Weights
Wanmo KANG, Department of Mathematical Sciences, Korea Advanced Institute
of Science and Technology, Republic of Korea

Banking regulations set minimum levels of capital for banks. These requirements are generally formulated through a ratio of capital to *risk-weighted* assets. A risk-weighting scheme assigns a weight to each asset or category of assets and effectively functions as a linear constraint on a bank's portfolio choice; it also changes the incentives for banks to hold various kinds of assets. In this talk, we investigate the design of risk weights to align regulatory and private objectives in a simple mean-variance framework for portfolio selection. By setting risk weights proportional to profitability rather than risk, the regulator can induce a bank to reduce its overall level of risk without distorting its asset mix. Because the regulator is unlikely to know the true profitability of assets, we introduce an adaptive formulation in which the regulator sets weights by observing a bank's portfolio. The adaptive scheme converges to the same combination of weights and portfolio choice that would hold if the regulator knew the asset profitability. We also investigate other objectives, including steering banks to a target mix of assets, adding robustness, mitigating procyclicality, and reducing system-wide risk in a setting with multiple heterogeneous banks.

This is a joint work with Paul Glasserman at Columbia Business School.

Measuring Credit Risk of Individual Corporate Bonds and Deriving Term Structures of Default Probabilities

Takeaki KARIYA, Graduate School of Global Business, Meiji University, Japan

No doubt, the importance of empirical credit risk analysis has ever been increasing not only in financial industries but also in business and even in government under increasing world-wide uncertainties. In this paper, basing our arguments on the model of pricing government bonds (GBs) in Kariya et,al (2012) and using corporate bond (CB) prices as our data source on credit, we first propose a measure of credit risk price spread (CRPS) for each CB relative to a GB-equivalent CB price. To choose an empirically effective CRPS measure, we test a hypothesis of no attribute preference with respect to investors' behaviors forming prices in the market of GBs. The results strongly reject the hypothesis against maturity preference as well as coupon preference. Secondly using the CRPS measure, a specific agency credit rating is shown to be ineffective for making credit-homogeneous groups of corporate bonds, where industry category is also used. To get our credit-homogeneous grouping, the CRPS measure is standardized by adjusting the differences of maturities and a three-stage cluster analysis is applied to the observed standardized CRPSs for Japanese CBs to get 14 groups, where 1545 CB prices as of 2010.8 are included. Since the grouping by the cluster analysis is a posterior grouping which is based on stochastically realized CBs and GBs, we propose Fixed Interval Rating (FIR) Method based on the standardized CRPS, and form 10 credit homogeneous groups. Thirdly, we derive the term structures of default probabilities (TSDPs) for some cluster groups and FIR groups and some individual firms via Kariya (2012) model, where industry factor is also considered. Naturally the TSDPs reflect the investors' future perspective on defaults of individual firms or groups.

Authors: Takeaki KARIYA, Yoshiro YAMAMURA, and Koji INUI, Graduate School of Global Business, Meiji University, Japan; Zhu WANG, ZW System

Key words and phrases: credit risk price spread (CRPS), corporate bond, cluster analysis, term structure of default probabilities (TSDP), investors' behavior in the government bond market, default intensity model, fixed interval rating (FIR)

Credit-Equity Modeling Under a Latent Lévy Firm Process

Masaaki KIJIMA, Graduate School of Social Science, Tokyo Metropolitan University, Japan

Recent empirical studies have demonstrated the informative nature of the equity returns in explaining the variation of the underlying firm's credit default swap (CDS) spreads. Motivated by these findings, we propose a unified credit-equity model by extending the latent structural model in Kijima et al. (2009). As in the original latent model, we treat the actual status of the firm to be unobservable and one can extract information from the marker process that is observable to the investors. Default occurs when the actual firm value drops below a default threshold for the first time. Different from the model in Kijima et al. (2009), however, we define the marker process to be the firm's equity process. Choosing firm's equity process to be a market process subsequently relaxes the restrictions imposed in Kijima et al. (2009), enabling us to price firm-related securities.

Additionally, we enrich the original latent structural model with jump and regime-switching dynamics. The purpose of the extensions is to capture more realistic credit spreads and implied volatility skews under different economic environments. The proposed model maintains analytical tractability even under such complex dynamics, for the prices of CDSs and equity options admit semi-closed-form solutions. In sum, our model can evaluate corporate securities and their derivatives in a unified framework.

Authors: Masaaki KIJIMA, Graduate School of Social Sciences, Tokyo Metropolitan University, Japan; Chi Chung SIU, Finance Discipline Group, Business School, University of Technology, Sydney, Australia.

Statistical Inference Using Maximum-Correlation Portfolios

Robert KIMMEL, National University of Singapore, Singapore

We examine econometric issues in a formulation of linear factor models where the factors are replaced by their projections on the span of excess returns. Besides providing new asymptotic results, we derive the exact distribution and moments of the estimates of risk premia on maximum-correlation portfolios and related test statistics. A new model selection test statistic is also derived.

Computational Issues Related to Sequential Monte Carlo Filter and Smoother

Genshiro KITAGAWA, Research Organization of Information and Systems, Japan

Progress in information technologies has enabled to apply computer intensive methods to statistical analysis. In time series modeling, sequential Monte Carlo method (particle filter) was developed for general nonlinear non-Gaussian state-space models and it enables to consider very complex nonlinear non-Gaussian models for real-world problems. In this talk, we consider several computational problems related to sequential Monte Carlo filter and smoother, such as the use of a huge number of particles, two-filter formula for smoothing, and parallel computation. The posterior mean smoother and the Gaussian-sum smoother are also considered.

A Semi Markov Model for Market Microstructure and High-frequency Trading

Huyen PHAM, University Paris Diderot (Paris 7), France

The aim of this work is to construct a model for asset price in a limit order book, which captures on one hand main stylized facts of microstructure effects, and on the other hand is tractable for dealing with optimal high frequency trading by stochastic control methods. For this purpose, we introduce a model for describing the fluctuations of a tick-by-tick single asset price, based on Markov renewal process. We consider a point process associated to the timestamps of the price jumps, and marks associated to price increments. By modeling the marks with a suitable Markov chain, we can reproduce the strong mean-reversion of price returns known as microstructure noise. Moreover, by using Markov renewal process, we can model the presence of spikes in intensity of market activity, i.e. the volatility clustering. We also provide simple parametric and nonparametric statistical procedures for the estimation of our model. We obtain closed-form formulae for the mean signature plot, and show the diffusive behavior of our model at large scale limit. We illustrate our results by numerical simulations, and find that our model is consistent with empirical data on futures Euribor and Eurostoxx. In a second part, we use a dynamic programming approach to our semi Markov model applied to the problem of optimal high frequency trading with a suitable modeling of market order flow, and taking into account in particular the adverse selection risk. We show a reduced-form for the value function of the associated control problem, and provide a convergent and computational scheme for solving the problem. Numerical tests display the shape of optimal policies for the market making problem.

The Affine Nature of Aggregate Wealth Dynamics

Eckhard PLATEN, University of Technology Sydney, Australia

The presentation derives a parsimonious two-component affine diffusion model for a world stock index to capture the dynamics of aggregate wealth. The observable state variables of the model are the normalized index and the inverse of the stochastic market activity, both modelled as square root processes. The square root process in market activity time for the normalized aggregate wealth emerges from the affine nature of aggregate wealth dynamics, which will be derived under basic assumptions and does not contain any parameters that have to be estimated. The proposed model employs only three well interpretable structural parameters, which determine the market activity dynamics, and three initial parameters. It is driven by the continuous, nondiversifiable uncertainty of the market and no other source of uncertainty. The model, to be valid over long time periods, needs to be formulated in a general financial modelling framework beyond the classical no-arbitrage paradigm. It reproduces a list of major stylized empirical facts, including Student-t distributed log-returns and typical volatility properties. Robust methods for fitting and simulating this model are demonstrated. The model can be applied in various areas where long term real world index dynamics are relevant, including actuarial studies, as well as, derivative pricing and hedging.

This is a joint work with Renata Rendek.

Modeling Term Structure of Default Correlation

Sira SUCHINTABANDID, Department of Banking and Finance, Chulalongkorn University, Thailand

Multiname credit modeling requires one to specify not only the default probability of each name but also the correlation among defaults. Default probability varies with time horizon, and therefore admits a “term structure” which, in practice, can be extracted from credit instruments of different maturities in a manner similar to how term structure of interest rates is extracted from default-free bonds of different maturities. This paper stems from the notion that default correlation, too, admits a “term structure” which can be readily implied from the market. We first discuss the challenges in modeling the term structure of default correlation and then propose, as an alternative to existing models of correlated defaults, a new framework that circumvents those challenges. The proposed model not only offers competitive tractability, but also enables one to impose a *term structure* of correlation upon any pair of entities without affecting the marginal distributions of their default times. The model thus greatly facilitates calibration: Once the term structure of marginal default probabilities is extracted from the single-name instruments (such as CDSs), the term structure of default correlation can then be extracted either from the “correlation products” (such as index tranches), or from the joint default probabilities implied by the co-movement between prices of single-name instruments. The paper also discusses some applications of the model. As an example, we argue that term structure of correlation plays an important role in generating the so-called correlation skew observed in the market for index tranches. Subsequent calibration result confirms this view.

Parameter Estimation Using Empirical Likelihood Combined with Market Information

Zhiliang YING, Columbia University, USA

We are concerned with the use of empirical likelihood methodology to estimate parameters of various diffusion processes. In addition to returns, other market information such as actively traded derivative prices may also be available. This leads us to developing an empirical likelihood based method that naturally combines the return series and the associated derivative prices for parameter estimation. We show that the resulting estimators possess nice asymptotic properties under reasonable assumptions. Simulation results and case studies are presented to demonstrate the feasibility and effectiveness of the proposed method.

This talk is based on joint work with Steven Kou and Tony Sit.

ABSTRACTS
Contributed Talks



Optimal Execution with Transient Impact

Ngoc-Minh DANG, Quantitative and Computational Program, John von Neumann Institute - Vietnam National University HCMC, Vietnam

We deal with the optimal execution problem in which we consider the model of asset prices with transient impact as proposed in Gatheral (2008) and minimize a mean-variance functional of the execution cost. Using a non-classical result on calculus of variations, we obtain an integral equation characterizing the optimal strategy. The latter takes the form of a Fredholm integral equation of the second kind, we then provide a scheme to solve it numerically and verify indeed some no-arbitrage conditions.

Key words: Transient impact; optimal execution; Jim-Gatheral model; mean-variance optimization

From Empirical Behaviors to ARCH Modeling

Ling FENG, Department of Physics, National University of Singapore, Singapore

From certain empirical behaviors in financial market, we derive a stochastic model that is ARCH-like. The main behaviors incorporated in this model are convergence of opinions among technical traders and their heterogeneous investment horizons. Its first behavior is found to explain the fat-tail distribution of returns, and the second explains the long memory in volatility. An explicit relation between the behaviors and the two stylized facts are given in terms of mathematical relations, which is verified empirically. The model sheds some light on the apparent critical phenomenon of financial time series, and provides some behavioral interpretation to ARCH formulation.

Authors: Ling FENG and Baowen LI, National University of Singapore, Singapore; Boris PODOBNIK and H. Eugene STANLEY, Boston University, Boston.

Long-Term Compensation and Managerial Choice of Effort and Risk

Luis GONCALVES-PINTO, Department of Finance, National University of Singapore, Singapore

We study the incentive effects of compensating a risk-averse manager with restricted stock of the firm she manages. The manager can only sell the firm stock after a predetermined lockup period. In a continuous-time portfolio choice framework, we allow the manager to apply costly effort and to be able to select the level of risk of her investments, which in turn affect the expected value and volatility of the firm she manages. We also allow the manager to be able to partially hedge the risk of the restricted stock by taking offsetting positions on a market index. We show that the liquidity constraints associated with the restricted stock can endogenously generate large managerial risk aversion. We show that the maximum amount of effort selected by the manager declines over the lockup period. Moreover, in order to induce maximum effort throughout the lockup period, the manager needs to be offered increasing amounts of restricted stock over that period. Lastly, we show that the subjective value of the restricted stock is a hump-shaped function of the level of diversification of the manager's personal portfolio.

Authors: Min DAI, Luis GONCALVES-PINTO, Yaoting LEI, National University of Singapore, Singapore

Analysis of Optimal Dynamic Withdrawal Policies in Withdrawal Guarantees Products

Yao Tung HUANG, Department of Mathematics, Hong Kong University of Science and Technology, Hong Kong, China

The guaranteed minimum withdrawal benefits (GMWB) are popular riders in variable annuities with withdrawal guarantees. With withdrawals spread over the life of the annuities contract, the benefit promises to return the entire initial annuitization amount irrespective of the market performance of the underlying fund portfolio. Treating the dynamic withdrawal rate as the control variable, the earlier works have considered the construction of a continuous singular stochastic control model and the numerical solution of the resulting pricing model. This paper presents a more detailed characterization of the behavior of the GMWB price function and performs a full mathematical analysis of the optimal dynamic withdrawal policies under the competing factors of time value of fund, optionality value provided by the guarantee and penalty charge on excessive withdrawal. When proportional penalty charge is applied on any withdrawal amount, we can reduce the pricing formulation to an optimal stopping problem with lower and upper obstacles. We then derive the integral equations for the determination of a pair of optimal withdrawal boundaries. When proportional penalty charge is applied only on the amount that is above the contractual withdrawal rate, we manage to characterize the behavior of the optimal withdrawal boundaries that separate the domain of the pricing models into three regions: no withdrawal, continuous withdrawal at the contractual rate and immediate withdrawal of finite amount. Under certain limiting conditions, we manage to obtain analytical approximate solution to the singular stochastic control model of dynamic withdrawal.

Authors: Yao Tung HUANG and Yue Kuen KWOK, Department of Mathematics, Hong Kong University of Science and Technology, Hong Kong, China

Endogenous Monetary Policy Shifts and the Term Structure: Evidence from Japanese Government Bond Yields

Junko KOEDA, Faculty of Economics, University of Tokyo, Tokyo, Japan

I construct a no-arbitrage term structure model with endogenous regime shifts and apply it to Japanese government bond (JGB) yields. This model subjects the short-term interest rate to monetary regime shifts, specifically a zero interest rate policy (ZIRP) and normal regimes, which depend on macroeconomic variables. The estimates show that under the ZIRP regime, the effect of deflation (inflation) on lowering (raising) bond yields amplifies on the long end of yield curves, compared with a case with positive interest rates under the normal regime. On the other hand, output gaps' ability to raise bond yields weakens for all maturities.

Optimal Stopping for Selling a Derivative based on a Generalized Black-Scholes' Model with Regime-switching

Yue LIU, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore

This paper deals with how to choose an optimal stopping time for selling a derivative based on a generalized Black-Scholes' model with regime-switching. Two approaches are made to solve it, the first one is to deduce it to an optimal stopping problem with the objective to select the optimal stopping strategy over all admissible stopping strategies, by which the investor may maximize his profit under given conditions, i.e.,

$\inf_{t \leq \tau \leq T} E \left[\sup_{0 \leq s \leq T} \frac{Y_s}{Y_\tau} \middle| \mathcal{F}_t \right]$ reaches its minimum, where Y_t denotes the asset price. Another method is to construct an approximation algorithm, where the process is divided into a sequence of geometry Brownian motion during each period that the Markov process produces no jumps. Two methods have the respective advantages and generate the similar results according to numerical testification.

Authors: Yue LIU and Nicolas PRIVAULT, School of Physical & Mathematical Sciences, Nanyang Technological University, Singapore

Measuring Market Risk for VIX Futures Strategies

Marco MARCHIORO, University of Milan, Italy, and Quant Island, Singapore

We describe a method to perform risk simulations of VIX futures and VIX-futures strategies, according to the historical-simulation model. We assume a stochastic-volatility mean-reverting constant-elasticity-of-variance process to model the VIX dynamics. Following non-arbitrage arguments the market expectation of VIX futures price results in a function of three financial variables: the spot VIX index, the long-term expected VIX value, and a time scale parameter. For each trading day in the period 2011-2012 we collect the closing VIX futures market quotes across all available maturities and calibrate the three financial variables using an ad-hoc least-squares procedure. We then compute historical scenarios for all financial variables and we apply these scenarios to single VIX futures and a calendar spread position. Finally, from the distribution of the simulated spread values we derive the profit-and-loss (P&L) strip used to compute risk figures.

Keywords: Risk management, risk measures, and volatility models

Authors: Marco Marchioro, Davide Borrello, and Leonardo D'Auria, University of Milan—Bicocca, Milan, Italy

A Robust Version of Convex Integral Functionals

Keita OWARI, Graduate School of Economics, The University of Tokyo, Japan

In recent studies in financial mathematics, robust formulations of stochastic optimization problems (hedging, optimal investment risk management and so on) have attracted growing attention in view of model uncertainty. Many of those problems amount (in an abstract sense) to minimizing on a certain convex set a functional of the form

$$\mathcal{I}_f(\xi) := \sup_{P \in \mathcal{P}} \mathbf{E}_P[f(\cdot, \xi)] = \sup_{P \in \mathcal{P}} \int_{\Omega} f(\omega, \xi(\omega)) P(d\omega), \quad \xi \in \mathbf{L}^\infty(\Omega, \mathcal{F}, \mathcal{P})$$

where (Ω, \mathcal{F}) is a measurable space, \mathcal{P} is a set of probability measures on it, $f: \Omega \otimes \mathbb{R} \rightarrow \mathbb{R}$ is a random convex function, and $\mathbf{L}^\infty(\Omega, \mathcal{F}, \mathcal{P}) =: \mathbf{L}^\infty$ is the set of \mathcal{P} -quasi surely bounded measurable functions modulo \mathcal{P} -q.s. equality. The set \mathcal{P} is interpreted as the collection of all possible models, which we assume convex and compact in a certain sense, but *do not assume dominated by a single probability measure* [cf. 1]. The goal of this talk is to establish a duality theory for this type of integral functionals in the spirit of the classical Rockafellar theorem, which provides a nice duality formula and existence of dual optimizer for robust stochastic optimizations in a considerable generality.

A key ingredient is the Fenchel-Legendre transform of \mathcal{I}_f^* :

$$\mathcal{I}_f^*(\nu) := \sup_{\xi \in \mathbf{L}^\infty} (\nu(\xi) - \mathcal{I}_f(\xi)), \quad \nu \in (\mathbf{L}^\infty)^*.$$

We first obtain a lower and an upper bounds for \mathcal{I}_f^* on the entire $(\mathbf{L}^\infty)^*$ (the norm dual), both of which are sums of a common regular part and respective singular parts, and they coincide when \mathcal{P} is a singleton recovering the classical Rockafellar duality. In general, the difference between the bounds can be strict, but our estimate is the best in a certain sense. We then discuss when \mathcal{I}_f^* “eliminates” the singular elements of $(\mathbf{L}^\infty)^*$, which *a fortiori* implies the equality of bounds. We provide some necessary and sufficient conditions for this property, which include finer regularities of \mathcal{I}_f^* w.r.t. the dual pairing $\langle \mathbf{L}^\infty, \text{ca}(\mathcal{P}) \rangle$ where $\text{ca}(\mathcal{P}) \subset (\mathbf{L}^\infty)^*$ is the space of (finite) *countably additive* signed measures on \mathcal{F} respecting \mathcal{P} -polar sets. Those regularities are all we need to develop a convex duality theory without singular terms for the robust optimization problems that motivated us.

We then conclude the talk with an application to an abstract form of robust utility maximization problem, providing a key duality formula and the existence of dual optimizer as well as some remarks on further developments.

References: [1] Owari, K. (2013): A robust version of convex integral functionals. arXiv:1305.6023.

Default Clustering and Valuation of Collateralized Debt Obligations **Xianhua PENG, Hong Kong University of Science and Technology, Hong Kong**

The recent financial turmoil has witnessed the impact of the default clustering effect (i.e., one default event tends to trigger more default events in the future and cross-sectionally), especially on the market of collateralized debt obligations (CDOs). We first present empirical evidences on default clustering via an observed common market intensity factor. Then, to price CDOs with the default clustering effects, we show the dynamic prices of CDOs can be decomposed into two parts, one part is related to observed single-name credit securities, such as credit default swaps (CDS), and the other the common market factors. The resulting model, which has only 4 parameters and is calibrated to individual CDS spreads exactly, seems to fit the iTraxx CDO tranche spreads observed during the financial crisis period reasonably well.

This is a joint work with Steven Kou.

Pricing Options with Absorption

Taiga SAITO, Graduate School of Economics, The University of Tokyo, Japan

We develop a new foreign exchange rate model with absorption for options pricing. The model takes into account the effect of intervention by a central bank or a government in arbitrage free framework. Moreover we derive closed form pricing formulas for European and digital put options under the model. We show numerical examples for the case of EURCHF where we see interventions by Swiss National Bank. We compare the prices of the absorption model with the ones observed in the market and examine features of the absorption modeling.

Investment Strategies under Debt Financing Constraints

Takashi SHIBATA, Tokyo Metropolitan University, Japan

We introduce debt issuance limit constraints along with market debt and bank debt to consider how financial frictions affect investment, financing, and debt structure strategies. Our model provides four important results. First, a firm is more likely to issue market debt than bank debt when its debt issuance limit increases. Second, investment strategies are nonmonotonic with respect to debt issuance limits. Third, debt issuance limits distort the relationship between a firm's equity value and investment strategy. Finally, debt issuance limit constraints lead to debt holders experiencing low risk and low returns. That is, the more severe the debt issuance limits, the lower the credit spreads and default probabilities. Our theoretical results are consistent with stylized facts and empirical results.

Authors: Takashi SHIBATA, Tokyo Metropolitan University, Japan; Michi NISHIHARA, Osaka University, Japan

Pricing Basket Options under Local Stochastic Volatility with Jumps

Kenichiro SHIRAYA, Mizuho-DL Financial Technology, Japan

We derive an approximation formula for basket option pricing in a model with local stochastic volatility and jumps.

In particular, the model admits a local volatility function and systematic jumps for not only the underlying asset price, but also its volatility process. Numerical experiment confirms the validity of our approximation formula.

Sparse Grid Techniques for Pricing Bermudan-style Options

Hideyuki TANAKA, Graduate School of Science and Engineering, Ritsumeikan University, Japan

We discuss pricing Bermudan-style options in several dimensions without Monte Carlo simulation. We consider an expansion of conditional expectations by basis functions in each time step. The sparse grid method plays an important role in avoiding the curse of dimensionality. This talk is based on the theoretical and computational results in [Tanaka, H., Higher-order interpolated lattice schemes for multidimensional option pricing problems, forthcoming in Journal of Computational and Applied Mathematics].

Calibration of Stochastic Volatility Models: A Tikhonov Regularization Approach

Ling TANG, National University of Singapore, Singapore

We aim to calibrate stochastic volatility models from option prices. We develop a Tikhonov regularization approach to recover the risk neutral drift term and diffusion term of the volatility (or variance) process which are assumed to be a deterministic function of instantaneous volatility (or variance) and time. In contrast to the existing literature, we do not assume that the model has any special structure. So our algorithm applies to calibration of general stochastic volatility models. Numerical results are presented to demonstrate the efficiency of our numerical algorithm.

This work is done jointly with Min DAI (National University of Singapore) and Xingye YUE (Soochow University, China).

Asymmetric Information and Investors' Options in Vietnam – Data Collected from the Ho Chi Minh City Securities Exchange

Tran Nguyen Ngoc Anh THU, University of Finance and Marketing (UFM), Vietnam

The Vietnamese stock exchange began operation in 2000. At that time, Ho Chi Minh City Securities Exchange was the only exchange in the country. VN Index is the proxy of the market. Trading activity in the beginning was very weak with very few public companies. Since 2006, trading activity has become more robust. The market erupted in 2007 with the VN Index reaching 1170; after that, it started cooling and bottomed in 2008 with the VN Index fell to 235. So far, the market has somewhat recovered but is still very weak. The VN Index ranged between 470-510 points. One thing to note is that when the market goes up, all the stocks go up, regardless whether they are good or bad; in contrast, when bad news comes out, all the stocks go down. Vietnamese stock market's development is highly influenced by a number of well-known newspapers such as the Tuoi Tre, Thanh Nien, Dau Tu, and Saigon Economic Times. This shows that a majority of stock investors imitates each other's behavior, exhibits herd mentality, due to lack of information. This study aims to analyze the impact of asymmetric information on the investors on the Ho Chi Minh City Securities Exchange in order to help investors better understand the companies they invest in, and from that, could determine the stock price more appropriate and conduct more efficient investment decision. Moreover, increasing the transparency of information on the stock market will help the market operate better and more efficiently.

Pricing Bounds on Quanto Options

Yukihiro TSUZUKI, Graduate School of Economics, The University of Tokyo, Japan

This paper proposes model-independent pricing bounds on quanto options and the corresponding replicating strategies, which are static ones whose portfolios consist of plain-vanilla options on the foreign asset and on the FX rate. Since they are derived model-independently, one can make profits with no risk if quanto options are priced outside the bounds. In addition, the pricing bounds can be improved if liquid quanto contracts such as quanto forward contracts are used for replication. Numerical examples show our pricing bounds comparing with the Black pricing formula and that with an ad-hoc adjustment.

Fredholm and PDE methods applied to Quadratic Functionals of the OU process

Hailing WU, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore

In this paper we compute the bivariate Laplace transform of quadratic Ornstein-Uhlenbeck (OU) functionals of the form

$$\left(\int_0^T X_t dB_t, \int_0^T X_t^2 dt \right)$$

where $(X_t)_{t \in \mathbb{R}_+}$ is a OU process driven by a standard Brownian motion $(B_t)_{t \in \mathbb{R}_+}$. Our method relies on expressions of the Carleman-Fredholm determinant of associated Volterra operators that are derived using PDE arguments and hypergeometric series. Classical and new bond pricing formulas in the CIR model are obtained as particular cases.

Keywords: Ornstein-Uhlenbeck process, quadratic Brownian functionals, exponential Brownian functionals, CIR model, bond pricing.

Authors: Nicolas Privault and Hailing Wu, School of Physical and Mathematical Sciences Nanyang Technological University, Singapore

An Asymptotic Expansion for Forward-Backward SDEs

Toshihiro YAMADA, Graduate School of Economics, The University of Tokyo, Japan

In this talk, we show a new closed-form approximation scheme for the forward-backward stochastic differential equations (FBSDEs). Our method is based on an asymptotic expansion in Malliavin calculus for the forward SDEs and the Picard iteration scheme for the BSDEs. We also show numerical examples for pricing derivatives with counterparty risk where the risky closeout credit value adjustment (CVA) is taken into account.

Authors: Akihiko TAKAHASHI and Toshihiro YAMADA, The University of Tokyo, Japan.

Empirical Credit Risk Analysis on Euro Government Bonds

Yoshiro YAMAMURA, Graduate School of Global Business, Meiji University, Japan

The Euro/Greece crisis that emerged in 2009 has caused considerable economic disruption in the Euro countries and elsewhere. In this paper we make an empirical study on the sovereign risk of Euro Countries during the period of Euro Crisis using the government bond (GB) price data. Based upon Kariya (1993), we firstly have estimated the attribute-dependent GB pricing model for Germany, France, Spain, Italy and Greece. The results imply the existence of attribute effects of bond pricing for almost periods, same as US Government Bond model (Kariya et. al (2013)). Secondly we propose the Credit Risk Price Spread of individual GBs(GB-CRPS) relative to German bond as a measure of sovereign risk for France, Spain, Italy and Greece. It is found that GB-CRPSs of Spain and Italy, as well as Greece, have been diversified after Greece Crisis and the sovereign risk of these countries became increasing. Thirdly we derive the term structures of default probabilities (TSDP) of France, Spain, Italy and Greece relative to German GB via Kariya (2012) model. Consequently we show that TSDP in each country is a linear function of the individual interest rate spread to German interest rate, and that the relations between CDS rates and TSDPs are also linear.

Authors: Takeaki KARIYA, Graduate School of Global Business, Meiji University, Japan; Yoshiro YAMAMURA, Graduate School of Global Business, Meiji University, Japan; Koji INUI, School of Interdisciplinary Mathematical Science, Meiji University, Japan; Yoko Tanokura, Graduate School of Advanced Mathematical Science, Meiji University, Japan; Zhu WANG, ZW System.

Pricing Bounds and Approximations for Discrete Arithmetic Asian Options under Time-changed Lévy Processes

Pingping ZENG, Department of Mathematics, Hong Kong University of Science and Technology, Hong Kong

We derive efficient and accurate analytical pricing bounds and approximations for discrete arithmetic Asian options under time-changed Lévy processes. We extend the conditioning variable approach to derive the lower bound on the Asian option price and construct a sharp upper bound based on the lower bound. We also consider the general partially exact and bounded (PEB) approximations, which includes the lower bound and partially conditional moments matching approximation as special cases. The PEB approximations are known to lie between a sharp lower bound and an upper bound. Our numerical tests show that the PEB approximations to discrete arithmetic Asian option prices can produce highly accurate approximations when compared to other approximation methods. Our proposed approximation methods can be readily applied to pricing Asian options under most common types of underlying asset price processes, including the Heston stochastic volatility model that is nested in time-changed Lévy processes with leverage effect.

Keywords: time-changed Lévy processes, arithmetic Asian options, conditioning variable approach, partially exact and bounded approximations

Authors: Pingping ZENG and Yue Kuen Kwok, Department of Mathematics, Hong Kong University of Science and Technology, Hong Kong

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Committee

ORGANIZING COMMITTEE

Tomio ARAI (University of Tokyo, Japan)

Min DAI (National University of Singapore, Singapore)

Steven KOU (Columbia University, USA)

Seisho SATO (University of Tokyo, Japan)

Akihiko TAKAHASHI (University of Tokyo, Japan)

Logistics

LECTURE VENUES

Invited talks will take place in Lecture Theatre 34 (level 3, block S17). The duration for each talk is 50 minutes (including discussion time).

Parallel sessions of contributed talks will take place in seminar room S17-04-04 and S17-04-05 (level 4, block S17). The duration for each contributed talk is 20 minutes (including discussion time).

The lecture theatres are equipped with desktop computer connected to LCD projector, projector screen, visualizer, overhead projector, white board, and separate connection for personal notebook/laptop.

MEALS

Tea breaks and lunches, served buffet-style at the foyer of the lecture theatre, are catered from a Halal-certified supplier. Usually some of the food items would be suitable for vegetarians.

Dinners are not included. Nevertheless, a wide variety of food at affordable prices (from S\$2.00) is available in the non-air-conditioned canteen and air-conditioned cafe near the venue for talks. More canteens, fast food outlets and restaurants are found in other parts of the campus (refer to Zonal Map). Some are less than 10-minutes' walk away from the conference venue while some are accessible by internal shuttle bus. Some stalls may open as early as 7.30am and close as late as 8.00pm. Halal and Vegetarian options are available in all canteens on campus.

LIBRARIES

There are seven multi-disciplinary and special libraries in NUS. The Central Library, for instance, is a multi-disciplinary library with a collection that covers architecture, building and real estate, engineering & technology, arts, humanities and social sciences. The Science Library is a special library that holds collections covering primarily the biological sciences, chemistry, computer science, mathematics, statistics & applied probability, materials science and physics. The Science/Medical Library is located on levels 3 to 6, block S6. All libraries are controlled by smart-card access but a special arrangement has been made to allow workshop participants to enter the libraries with their name tags during the workshop period (also need to complete a form on-site and provide Passport Number for record tracking). Participants may browse/read the materials in the library without loan privileges.

Operating hours of the libraries during workshop period:

Science/Medical/Central Libraries: 8.30am – 7.00pm (Monday – Friday)
10.00am – 5.00pm (Saturday)

Hon Sui Sen Memorial Library: 8.30am – 6.00pm (Monday – Friday)
10.00am – 5.00pm (Saturday)

Music Library: 8.30am – 6.00pm (Monday – Friday)

INTERNET ACCESS & USE OF COMPUTERS

A computing lab (S17-03-02) will be open for participants' access during the event period. It is located at level 3 of block S17 and consists of 42 desktop units that are internet-ready and installed with Windows 7, standard Microsoft Office applications, SSH, Adobe Reader, MATLAB. Limited WI-FI accounts would also be made available during event period for the convenience of those using personal notebook/laptop.

Operating hours: 8.30am – 6.00pm (Wednesday – Thursday)
 8.30am – 5.30pm (Friday)

Participants will have to request for account name and password to use either the computer in the computing lab, or for WI-FI access on their own notebook/laptop. Approach the IT support staff for account name and password (subject to availability).

FAX SERVICE

Participants who wish to send faxes may do so at the general office of the Department of Mathematics (level 4, block S17). This service is chargeable at a flat rate of S\$0.50 per page.

Operating hours: 8.30am – 6.00pm (Monday – Thursday)
 8.30am – 5.30pm (Friday)

GETTING AROUND NUS

The internal shuttle buses A, B, C, D, and UT-FoS (free-of-charge) serve the Kent Ridge campus.

Bus A1 and A2 cover substantial parts of the campus. A1 stops outside Kent Ridge MRT station, near NUH Staff Canteen and opposite S17 while A2 stops outside S17, opposite NUH Staff Canteen and opposite Kent Ridge MRT station. Bus A1E and A2E operates during term time on weekdays except public holidays. Bus A1E operates from 7.30am to 9.00am and stops outside Kent Ridge MRT station, and opposite S17. Bus A2E operates from 5.30pm to 7.00pm and stops outside S17, and opposite Kent Ridge MRT station.

Bus B is a loop service that serves Kent Vale and the other part of the campus. It does not stop at or anywhere near S17.

Bus C is a loop service that serves Kent Vale. It stops in front of and opposite S17.

Bus D is a loop service that serves the University Town. Bus D2 stops outside Kent Ridge MRT, opposite S17, University Town, outside S17 and opposite Kent Ridge MRT.

Bus UT-FoS is a direct service provided during term time on weekdays except public holiday at 9.40am, 9.50am, 11.40am, 11.50am, 1.40pm, 1.50pm, 3.40pm, and 3.50pm. Bus UT-FoS stops only at University Town and opposite S17.

More details on NUS internal shuttle bus can be found at:

<http://www.nus.edu.sg/oed/services/transport/shuttle-bus-services.htm>

The public bus SBS95 stops at the same stops as A1 and A2 between S17 and Kent Ridge MRT station. It also stops near and opposite Buona Vista MRT station (which is off-campus).

General

PUBLIC TRANSPORTATION

The public transport network in Singapore consists of bus, MRT (Mass Rapid Transit), LRT (Light Rail Transit) and taxi. Buses and MRTs are the most affordable modes of public transport with standard fares ranging from S\$1.00 to S\$2.20 (depending on distance). Bus fares are charged on board by tapping a stored-value card or paying the exact fare in Singapore currency to the driver.

MRT fare is paid by tapping a Stored Value Card or a Standard Ticket at the gantry. The Standard Ticket can be used up to six times within 30 days from the date of purchase. The purchase price includes a deposit of 10 cents and this is automatically refunded on the travel fare of the third trip. A user also enjoys a 10-cent discount on the sixth trip. The Standard Ticket can be purchased at the General Ticketing Machine (GTM) at all MRT and LRT stations. LRTs are only available in selected residential neighbourhoods and operate similarly as MRTs.

Typically, the first bus and train starts running at 5.30am and the last service is 11.30pm daily. Special night bus services with specific routes that charge a flat rate of S\$3.00/S\$3.50 are available from 11.30pm to 4.30am on Fridays, Saturdays and eves of Public Holidays.

Taxis can be flagged down 24 hours a day on most roads or at taxi-stands outside most major shopping centres and hotels. There is no need to bargain for prices as the taxis are all metered. The basic fare consists of a flag-down fare and a metered fare. The flag-down fare for the first kilometer is between S\$3.00 and S\$5.00, depending on the type of taxi (regular or premium). The metered fare after the first kilometer is based on the distance and waiting times during the journey. Additional charges may also be incurred depending on the time of travel and origin of the journey. A detailed rates guide is posted on the rear door of each taxi for reference.

More information on public transport can be found at:

www.publictransport.sg/content/publictransport/en/homepage/CommutersGuide.html

GETTING TO THE AIRPORT

The easiest way to get to the airport is by taxi. For reference, the journey from NUS with smooth traffic would take about 30 minutes and cost about S\$25.00 without surcharge. Surcharges may be incurred depending on time of travel and if the taxi was pre-booked via phone.

To get to the airport by MRT (Mass Rapid Transit), connect to the East-West line (green line) going in the direction of Pasir Ris/Changi Airport. The Changi Airport MRT station is located under Terminals 2 and 3 which are connected to Terminal 1 by sky train. A one-way MRT fare from Kent Ridge station is about S\$2.30 (using the Standard Ticket) and takes approximately 57 minutes. More Information on MRT Network Map and fare can be found at:

<http://www.smrt.com.sg/Trains/NetworkMap.aspx>

FOOD & SHOPPING

Food centres and food courts serving local, Asian and sometimes international cuisine at affordable prices are commonly found in neighbourhoods and shopping malls. There would usually be at least one each of Halal and vegetarian stalls in most establishments. Operating hours of the stalls vary but most of them open by 10am and close by 9pm.

Restaurants and cafes are usually found in shopping malls and bigger neighbourhoods. Operating hours depend on the types of meals served but most would be open between 11.00am and 9.00pm.

Most shopping malls in Singapore operate from 11.00am to 10.00pm every day.

BANK SERVICES & FOREIGN EXCHANGE

Participants may use major credit cards to withdraw cash using the Auto Teller Machines, which can be found in various locations on campus. Alternatively, the local banks offer regular banking services including processing foreign exchange and traveler's cheques. The nearest branches are:

DBS (Holland Village Branch)

Address: 257 Holland Avenue, Singapore 278984

Operating hours: 8.30am – 4.30pm (Monday – Friday)
8.30am - 1.00pm (Saturday)

DBS/POSB (NUS Remix Branch)

Address: 31 Lower Kent Ridge Road, #01-02 Yusof Ishak House, Singapore 119078

Operating hours: 8.30 AM - 4.30 PM (Monday to Friday)
8.30 AM - 1.00 PM (Saturday)

Only Personal Banking Services are available. Demand Draft and Remittance services are not available. All cash transactions must be made at Automated Teller Machines.

POSB (Buona Vista Branch)

Address: Blk 43 Holland Drive #01-59, Singapore 270043

Operating hours: 8.30am – 4.30pm (Monday – Friday)
8.30am - 1.00pm (Saturday)

UOB (Holland Village Branch)

Address: 211 Holland Avenue, #01-12 Holland Road Shopping Centre, Singapore 278967

Operating hours: 9.30am – 4.00pm (Monday – Friday)
9.00am - 12.30pm (Saturday)

PHONES & STAMPS

Public pay phones (cash and card) are available next to the male toilet at the foyer of Lecture Theatre 27 (opposite block S17). Pay phone cards and postage stamps can be purchased at the co-op below Lecture Theatre 27. Other goods and services available at the co-op include books, stationery, sundries and photocopying.

Operating hours (co-op): 9.00am – 6.00pm (Monday – Friday)

The Kent Ridge Post Office at Yusof Ishak House (three bus-stops from LT 27) provides a more comprehensive postal service.

Operating hours: 8.30am – 5.00pm (Monday – Friday)
8.30am – 1.00pm (Saturday)

USEFUL PHONE NUMBERS

Taxi (for current and advanced booking):

<u>Company</u>	<u>Telephone</u>	<u>Colour of vehicle</u>
CityCab	65521111	Yellow
Comfort Taxi	65521111	Blue
Premier Taxis	63636888	Silver
Prime Taxis	67780808	Copper (regular service); Blue (limousine service)
Smart Cab	64857777	Green (regular service); White (supreme service)
SMRT Taxis	65558888	White
Trans Cab	65553333	Red
Yellow Top Taxis	62935545	Yellow top with black body

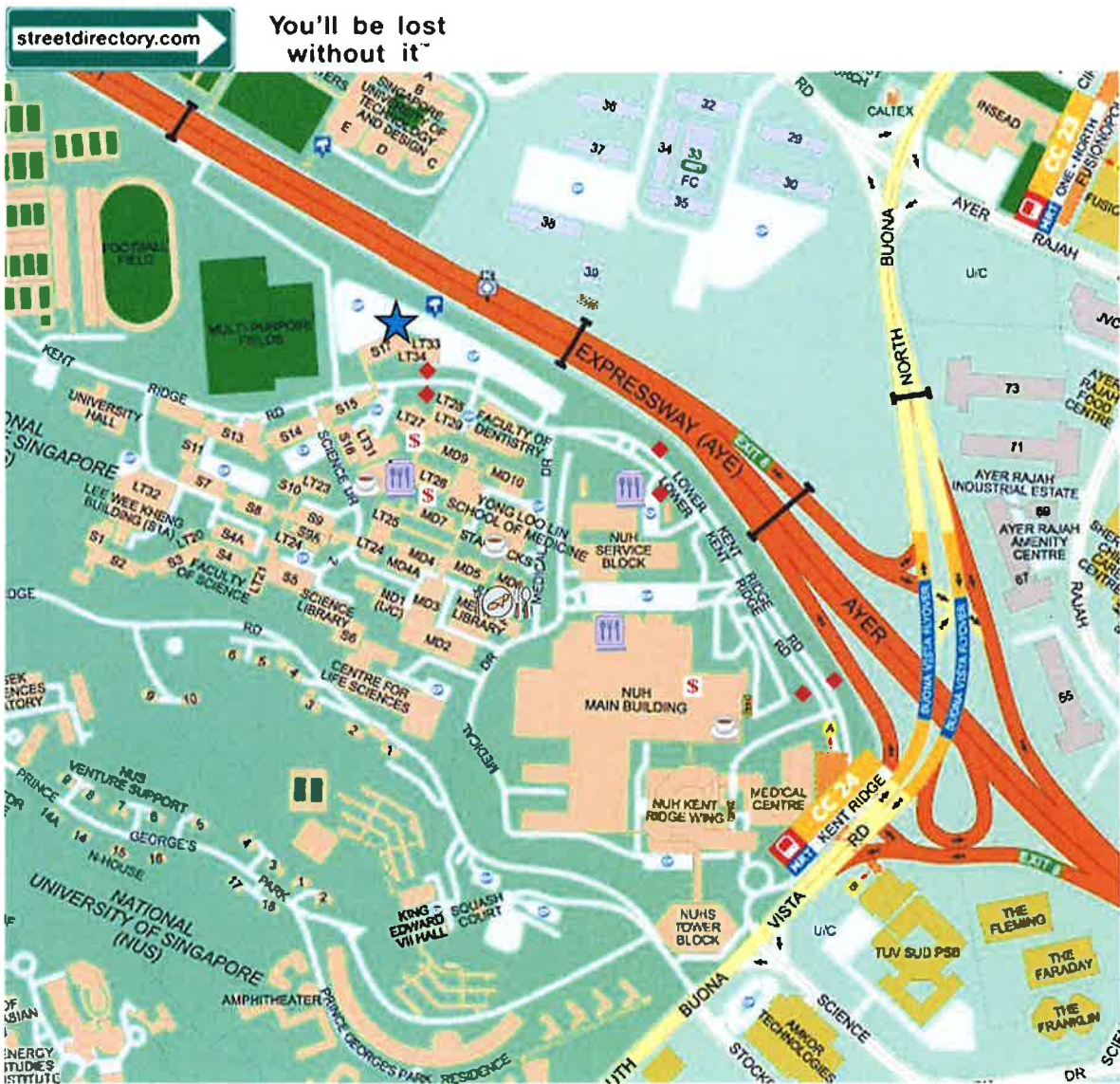
Local Emergency Services for Credit Cards:

American Express	62991997
Diner's Club Singapore	64160800 (during office hours); 64160800 (after office hours)
MasterCard	800-1100-113
Visa	800 4481 250







Others:

Tourist Information	1800-7362000
24-hour Flight Enquiry (Changi Airport)	1800-5424422
Buona Vista Neighbourhood Police Post	1800-7779999
Police Emergency	999
Non-emergency Ambulance	1777
Fire Engine/Ambulance	995

Zonal Map



Map powered by Streetdirectory.com

-  Workshop venue (S17)
-  Bus-stop
-  Canteen/Food Court
-  Restaurant
-  Coffee joints (Starbucks at School of Medicine; Spinelli at Science canteen; The Coffee Bean at NUH)
-  Auto Teller Machine