OPTION-IMPLIED ADJUSTED INFORMATION USING EXTENDED GENERALISED LELAND OPTION PRICING MODELS IN ASSET ALLOCATION STRATEGIES

BY

HANANI FARHAH BINTI HARUN

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Kulliyyah of Science
International Islamic University Malaysia

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ABSTRACT

Deciding an optimum asset allocation strategy is crucial, especially in view of market participants. However, to effectively decide an accurate strategy requires stable and unbiased portfolio, which can be achieved by reduced potential estimation error, an improved governing option pricing model and an effective portfolio strategy. This study provides an empirical analysis of option-implied volatility after correcting for possible estimation error using wavelet transform. So far, little attention has been paid in utilising wavelet transform in denoising the option-implied moments, especially within the model-guided nonparametric framework. Thus, this study primarily seeks to examine the effect of a continuous wavelet transform on option-implied information retrieved from Dow Jones Industrial Average (DJIA) index options throughout 2009 until the end of 2015. This study then extends the existing option pricing models by developing Extended Generalised Leland models based on the implied adjusted volatility introduced in Leland models. The proposed semiparametric models are developed to incorporate the transaction costs rate factor in the intermediated model-free framework to assure realistic pricing of options. We employ a nonparametric mechanism within the conventional option-pricing framework based on the Leland models in order to tackle both model misspecification problem introduced in most parametric models and the infeasible pricing problem in nonparametric models. Given the fact that selecting a portfolio with optimal asset allocation is a typical issue faced by many investors, this study extends the improved option-implied information in answering the asset allocation problems. This study finds that wavelet improves the error approximation of the signal. On top, this study reveals that the option-implied adjusted volatility, which is priced using the Extended Generalised Leland models, delivers a significant improvement to the option valuation accuracy. Superior option pricing accuracy was observed in the Extended Generalised Leland models. Results indicate that the proposed model has shown to improve asset allocation strategy significantly.

خلاصة البحث

إن تحديد الإستراتيجية المثلى لتوزيع الأصول أمر بالغ الأهمية، خاصة في نظر المشاركين في السوق. ومع ذلك، فمن أجل اتخاذ قرار فعال بشأن استراتيجية دقيقة تتطلب محفظة مستقرة وغير متحيزة، والتي يمكن تحقيقها عن طريق تقليل خطأ التقدير المحتمل، ونموذج تسعير خيار تحكم محسن واستراتيجية محفظة فعالة. تقدم هذه الدراسة تحليلاً تجريبيًا للتقلبات الضمنية للخيار بعد تصحيح الخطأ التقديري المحتمل باستخدام تحويل الموجات. حتى الآن، لم يتم إيلاء اهتمام كبير لاستخدام تحويل المويجات لإخفاء اللحظات التي ينطوي عليها الخيار، خاصة داخل الإطار غير المعياري الذي يوجهه النموذج. وبالتالي، تسعى هذه الدراسة في المقام الأول إلى فحص تأثير التحول المويجات المستمر على المعلومات الضمنية للخيار المستردة من خيارات مؤشر سوق الأوراق المالية (داو جونز) الصناعي (DJIA) من عام 2009 حتى نهاية عام 2015. ثم توسع هذه الدراسة نماذج تسعير الخيارات الحالية من خلال تطوير نماذج Leland المعممة الموسعة استنادًا إلى التقلبات المعدلة الضمنية المقدمة في نماذج Leland. تم تطوير نماذج شبه النظامية المقترحة لدمج عامل معدل تكاليف المعاملة في إطار وسيط خال من النماذج لضمان التسعير الواقعي للخيارات. تستخدم هذه الدراسة آلية غير معلمية ضمن إطار تسعير الخيارات التقليدية استنادًا إلى نماذج Leland من أجل معالجة كل من مشكلة أخطاء النموذجية المقدمة في معظم النماذج البارامترية ومشكلة التسعير غير المجدية في النماذج غير المعلمية. بالنظر إلى حقيقة أن اختيار محفظة ذات توزيع مثالي للأصول يمثل مشكلة نموذجية يواجهها العديد من المستثمرين، فإن هذه الدراسة توسع المعلومات الضمنية للخيار المحسنة للإجابة على مشاكل تخصيص الأصول. وجدت هذه الدراسة أن المويجات تعمل على تحسين تقدير الخطأ في الإشارة. علاوة على ذلك، تكشف هذه الدراسة أن التقلبات المعدلة الضمنية للخيار، والتي يتم تسعيرها باستخدام نماذج Leland المعممة الموسعة، تقدم تحسنًا كبيرًا في دقة تقييم الخيار. وقد لوحظت دقة تسعير الخيار الأفضل في نماذج Leland المعممة الموسعة. تشير النتائج إلى أن النموذج المقترح قد أظهر تحسنًا كبيرًا في استراتيجية تخصيص الأصول.

APPROVAL PAGE

The thesis of Hanani Farhah binti Harun has been approved by the following:

Mimi Hafizah Abdullah
Supervisor

Pah Chin Hee
Co-Supervisor

Mohd. Aminul Islam
Internal Examiner

Noriszura Ismail
External Examiner 1

Mohd Lazim Abdullah
External Examiner 2

Zaidul Islam Sarker
Chairman

DECLARATION

I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Hanani Farhah binti Harun

Signature .... Date ....

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This thesis is dedicated for my loving and understanding husband and my beautiful daughter, who are always there together with me completing this journey.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
ANN	Artificial Neural Network
ANOVA	Analysis of Variance
ARIMA	AutoRegressive Integrated Moving Average
ATM	at-the-money
BSM	Black-Scholes-Merton
CAPM	Capital Asset Pricing Model
CBOE	Chicago Board Options Exchange
CGMY	Carr-Geman-Madan-Yor
CST	Central Standard Time
CWT	Continuous Wavelet Transform
DJIA	Dow Jones Industrial Average
DJX	Dow Jones Industrial Average Index Options
DOTM	Deep-out-of-the-money
DVF	Deterministic Volatility Function
DWT	Discrete Wavelet Transform
ETF	exchange-traded funds
ETP	exchange-traded products
FDR	False Discovery Rate
FX	foreign exchange
GARCH	Generalised AutoRegressive Conditional Heteroskedasticity
GLI	Generalised Leland-Infused
GOWDA	Generalised Optimal Wavelet Decomposing Algorithm
HVRP	Historical Volatility Risk Premium
IAV	Implied adjusted volatility
ITM	in-the-money
L85	MFIL Leland (1985)
LCASH	MFIL All-Cash
LSTOCK	MFIL All-Stock
LLSA	Local Linear Scaling Approximation
MAR	Multiscale Autoregressive
MARPE	mean value of the absolute relative pricing error
MEM	Mixture of Expert Models
MF	model-free
MFBKM	Model-Free Bakshi-Kapadia-Madan
MFIL	Model-Free Implied Leland
MFIV	Model-free implied volatility
MFIS	Model-free implied skewness
EGL	Extended Generalised Leland
MLE	Maximum Likelihood Estimation
MLR	Multiple Linear Regression
MN	Moneyness
MODWT	Maximal Overlap Discrete Wavelet Transform
MRMR	Multi-resolution Multirate
MRPE	mean value of the relative pricing error

MSVAR	Markov-Switching Vector AutoRegressive
NYSE	New York Stock Exchange
OIAM	Option-implied adjusted information
OTM	out-of-the-money
PLS	Partial Least Square
PNOAI	Portfolios without Option-implied Adjusted Information
POAI	Portfolios with Option-implied Adjusted Information
R_P	portfolio returns
RMC	Risk Management Conferences
RMSE	Root-Mean-Square-Error
RSOM	Recurrent Self-Organising Map
S&P 500	Standard & Poor’s 500
SARIMA	Seasonal AutoRegressive Integrated Moving Average
SD	standard deviation
SE	squared error
SNR	Signal-to-Noise Ratio
SR	Sharpe Ratio
STFT	Short-Time Fourier transform
SURE	Stein’s Unbiased Risk Estimate
SV	Stochastic Volatility
US	United States
VIX	CBOE Volatility Index
WNN	Wavelet Neural Network
WT	Wavelet Transform

CHAPTER ONE

INTRODUCTION

This chapter outlines an overview of the entire study. This includes a brief background of the study as a whole in Section 1.1. The main research questions underpinning the study are explored in the subsequent section, Section 1.2. Section 1.3 entails how the research questions are answered by the research objectives. The significance of this study is highlighted in Section 1.4. Section 1.5 elaborates on how this thesis is constructed.

1.1 BACKGROUND OF STUDY AND MOTIVATIONS

Option pricing has continued to be immensely practical either by its theory per se or its application. Owing to this fact, a large number of researchers tend to shed their light by focusing on this realm of work. The attention has been phenomenal especially since the extensive study by Black and Scholes (1973) and Merton (1973) in developing option pricing models. They are referred to here as the Black-Scholes-Merton (BSM) model. The model has been acknowledged as a standard theory in finance and has marked a cornerstone in option pricing model development. The BSM model is the most extensively used model, despite its impractical and complex assumptions[1]. A study conducted by Galai (1983) showed that the BSM model produced substantial pricing bias systematically. This has motivated a great number of studies to improve the option pricing model. The generalisation of the BSM model leads to the rapid growth of evolution in the modern parametric option pricing models.

[1] The assumptions are detailed in Section 2.3.1.1, page 27.

The modern parametric option pricing models which attempt to generalise and relax the assumptions built within the BSM model has demonstrated to be comprehensive in pricing options. Among the parametric models introduced are Heston, Stochastic Volatility, Gaussian, Variance Gamma and Carr-Geman-Madan-Yor (CGMY) models. Most parametric models are developed to handle the jump-diffusion and stochastic-volatility features of the true-data market dynamics. However, the generalisations often lead to overfitting and misspecifying classes of parametric models. The modern parametric approaches as highlighted by Lajbcygier (1999) often lead to poorly and extremely constrained models. They failed to outperform even simple and easy models (Bakshi, Cao, & Chen, 1997; Bakshi & Chen, 1997). These generalised models which utilise unrealistic parameters are exposed to over-parametrisation problems which often lead to significant pricing bias (Rubinstein, 1985; Fan & Mancini, 2009). This is understandable since these conventional parametric models inclined to produce parameters inconsistent with the underlying time series without costing the elimination of the systematic pricing bias (Radzikowski, 2000).

The quest to find one ideal and powerful option pricing model to explain option prices seems to be impossible at this rate. This has urged many insightful studies to consider complementary nonparametric approach instead. This approach presumes no complex model in deducing prices, unlike the conventional parametric approach. It is apparent that the complex parameterisation feature of the parametric approach serves the main door to significant erroneous option pricing. Alternatively, the option price is directly deduced from the historical data based on the nonparametric approach. In spite of that, rational and realistic option pricing is not assured in the nonparametric method[2] (Ghysels, Patilea, Renault, & Torrès, 1997). Radzikowski (2000) underlined that the ultimate option pricing model is not at one of the ends, but may be in the middle which integrates both approaches. This is indeed a fertile ground that offers a promising avenue for further exploration in which this study attempts to fill into.

The model introduced by Black and Scholes (1973) and Merton (1973) rests on the assumptions of no-arbitrage, pricing log-normality and frictionless trading. Therefore, the introduction of this BSM model in the 1970s has invited ample critics. Owing to the pitfalls of the BSM model in pricing options, the volatility implied from this model is unable to directly proxy the true expectation of future realised volatility (Shu & Zhang, 2003). Henceforth, a number of models have been developed to modify and tackle the pitfall introduced by the BSM model. Leland (1985) is among the first that improved the BSM model by developing a hedging strategy that incorporates adjusted volatility. The volatility is adjusted with respect to the length of rebalancing intervals, proportional transaction costs rate and the volatility of the underlying asset. One of the BSM assumptions is zero transaction costs. Leland (1985) model relaxed the assumption by forcing the length of the rebalancing intervals to approach zero. Zero hedging error can be achieved in the limit. Even though the idea is quite relevant, this model does not integrate the initial cost of trading into the assumptions. In response to the drawbacks of the original model, Leland (2007) provided two adjustments; namely Leland (2007) All-Cash model and Leland (2007) All-Stock model. In these models, the author explicitly considered initial costs of trading into the assumption that the initial portfolio is either consists of all cash or all stock positions.

Despite the fact that the BSM model has a few drawbacks, yet it is still acknowledged by many studies as a relevant option pricing model (Figlewski, 2002;

[2]The nonparametric pricing model is independent from the assumption of finance theory. It does not reflect the realistic and dynamic market situation as emphasized in parametric assumptions.

Christoffersen & Jacobs, 2004; An & Suo, 2009). The introduction of the BSM model to the financial market has inspired numerous literature to examine the forecasting ability of implied volatility in the time series framework (Chernov, 2001). This framework is shared by the Leland models. On top of that, a model which considers realistic transaction costs seems to be more suitable in handling options. It is anticipated that using the Leland option pricing models which share a roughly identical framework to that of the BSM model and incorporate the stochastic nature of volatility in its model appears to be relevant in this study. This research employs the Leland (1985) model and its two variations in estimating the option-implied information, namely *option-implied adjusted information*.

Option-implied information is inferred from the option prices. It is also referred to as forward-looking option-implied moments. This approach can be perceived as an alternative to the backward-looking approach that depends on historical data. Owing to its forward-looking nature, these option-implied moments able to comprehensively capture the derivatives market perception better than that of the historical data (as reviewed in Kempf, Korn and Saßning (2014)). It is then expected that the estimation which is carried out based on these forward-looking implied moments to perform better than that of the backward-looking in constructing an optimal portfolio. This is evident in many empirical studies that attempt to estimate these option-implied moments in a number of ways (Aït-Sahalia & Brandt, 2008; Kostakis, Panigirtzoglou, & Skiadopoulos, 2011; DeMiguel, Plyakha, Uppal, & Vilkov, 2013). This research attempts to differ from others in several dimensions. Instead of focusing on how to deliberately improve the existing work expansion on option pricing model in the parametric model framework, this study aims to employ nonparametric mechanisms in conventional option-pricing framework to assure realistic pricing of options.

Existing option pricing models are extended in this study by applying Leland (1985) model and the two Leland (2007) models to be intermediated within a semiparametric framework. This model-guided nonparametric framework is then referred to as Extended Generalised Leland (EGL) models throughout this study. Based on the EGL models, this study generates new option-implied adjusted moments. In this study, the Leland models are applied in a model-free framework, developed by Bakshi, Kapadia and Madan (2003). The proposed models are considered to reduce the model misspecification errors introduced by the Leland models, while still deliver realistic pricing. Rather than utilising the BSM model directly, this study employs the model-free framework of Bakshi et al. (2003) as the benchmark model. The benchmark model is denoted as Model-Free Bakshi-Kapadia-Madan (MFBKM) throughout this study. To employ the BSM model as the benchmark model is not suitable since the main interest of this study is on option-implied information. Unlike the BSM model, the MFBKM model deals with both call and put option prices simultaneously. This provides a shorter time computation-wise as well as by decision-wise. Following that, this research concentrates on extending the option-implied adjusted information to improve asset allocation strategies.

Optimising or selecting a portfolio with optimal asset allocation has been well acknowledged as a typical classic issue faced by investors. The theoretical study on improving asset allocation strategies has been the main focus of many researchers. This is obvious especially after the seminal study done by Markowitz (1952). The fact that option information is proven to efficiently encapsulate derivative market perception has triggered many others to study the optimal selection of asset allocation by exploiting the option moments. A great number of studies tend to utilise historical return data in estimating the option moments. However, a portfolio that is based on