In memory of my father Daqun Chang

A Consistent Approach to Modelling the Interest Rate Market Anomalies Post the Global Financial Crisis

A Thesis Submitted for the Degree of
Doctor of Philosophy

by

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October 10th, 2014

Certificate

I certify that this thesis has not previously been submitted for a degree nor has it been submitted as part of requirement for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signed .....

Date .....

Acknowledgments

First and foremost, I would like to thank my principal supervisor Professor Erik Schlögl. I appreciate his patience, guidance and dedication to supervision. Erik's visionary and straightforward approach to supervision has proven to be critical for the completion of my thesis. I would also like to thank my alternate supervisors Professor Carl Chiarella and Dr Kristoffer Glover for their additional supervision.

I would like to thank the following people at the Discipline of Finance of the UTS Business School for helpful discussions and moral support: Nadima El–Hassan, Tony Hall, Tony He, Boda Kang, Otto Konstandatos, Kai Li, Eckhard Platen, Chi Chung Siu, Jianxin Wang, Swee Guan Yap, Qinan Zhai and Tianhao Zhi.

I appreciate the financial assistance from the Australian Postgraduate Award and Quantitative Finance Research Centre at UTS.

I thank my mother, Liying Yang, who has been a constant source of encouragement and love. My wife, Xiaoxiao Li, has been extremely supportive and understanding of my studies. Without their love and support, I would not have possibly completed my PhD

thesis.

Finally I would like to dedicate the thesis to my father, Daqun Chang, who passed away in 2009. For many years he had supported my pursuit of academic excellence. He will always be remembered and loved by me.

Contents

Glossary of Abbreviations

ATM = At the money;

ATMVOL = At the money volatility;

BF = Butterfly;

BP = Basis Pay;

bps = Basis Point (1bp = 0.0001);

BR = Basis Receive;

BS = Liquidity Basis;

CCS = Cross–Currency Swap;

CCBS = Cross–Currency Basis Swap;

CDS = Credit Default Swap;

CIR = Cox–Ingersoll–Ross;

FF = Fed Funds;

FOR–DOM = Foreign–Domestic;

FRA = Forward Rate Agreement;

FX = Foreign Exchange;

GFC = Global Financial Crisis;

HJM = Heath–Jarrow–Morton;

IRDIFF = Interest Rate Difference;

IRS = Interest Rate Swap;

ITM = In the money;

LIBID = London Interbank Bid Rate;

LIBOR = London Interbank Offered Rate;

LMM = LIBOR Market Model;

MM = Market Maker;

OIS = Overnight Indexed Swap;

OTM = Out of money;

PCA = Principal Component Analysis;

PV = Present Value;

RR = Risk Reversal;

TS = Tenor Swap;

UIP = Uncovered Interest Rate Parity.

Abstract

The thesis is focused on the phenomenon of the cross–currency swap and tenor swap basis spread in foreign exchange (FX) and interest rate markets, which contradicts textbook no arbitrage conditions and has become an important feature of these markets since the beginning of the Global Financial Crisis (GFC) in 2007.

The results demonstrate empirically that the basis spread can not be explained by transaction costs alone and is therefore due to a new perception by the market of risks involved in the execution of textbook "arbitrage" strategies. We show that using the basis spread as a proxy for the market valuation of these risks, a better empirical explanation than hitherto found in the literature can be obtained for the "uncovered interest rate parity (UIP) puzzle," i.e. the phenomenon that carry trades taking advantage of interest rate differentials between different currencies have positive excess returns on average. Furthermore, considering the single–currency basis spread (the "tenor basis"), the empirical analysis of market data since the GFC has led us to a model which reduces the dimensionality of the tenor basis from observed term structures for every tenor pair down to term structures of two factors characterising the driving liquidity risk, and demonstrates that the tenor basis swap market is in the process of maturing since the turmoil of the

GFC.

There are three main contributions in this thesis. In Chapter 3 we examine the role of transaction costs in explaining the basis spread in cross–currency basis swaps. Based upon transaction costs, we derive bounds which should eliminate arbitrage in practice. The empirical results are consistent with the conventional market wisdom that to a large extent, transaction costs alone precluded arbitrage opportunities before the GFC. However, the no–arbitrage bounds have been persistently violated since the GFC. We propose that the market is prevented from exploiting such violations and making arbitrage profit by increased market imperfections, in particular the currency liquidity risk. These imperfections have resulted in forward and currency swap prices being determined by supply and demand pressures, rather than by arbitrage considerations.

In Chapter 4 we aim to explain the UIP puzzle by a model with liquidity risk. We empirically examine the effect of FX market liquidity risk on the excess returns of currency carry trades. Based upon Chapter 3 results, we use the violations of no–arbitrage bounds as the proxy for the market expectation of liquidity risk. The liquidity proxy, along with FX market volatility factors, is significant in explaining the abnormal returns of carry trades, particularly after the GFC. Our liquidity proxy is also statistically more significant than alternative proxies for liquidity risk in related studies. Our findings provide evidence that the UIP puzzle can potentially be resolved after controlling for liquidity risk.

In Chapter 5 and 6, we focus on the high–dimensional modelling problem existing in

the single–currency tenor swap market. Based on empirical results of recent studies, we propose an intensity–based model to describe the arrival time of liquidity shocks in the interbank market. With the no–arbitrage argument and non–linear constrained optimisations, we calibrate the model parameters to quoted basis spreads in tenor swaps. Our model reduces the dimensionality of the problem down to two factors: the intensity and the loss rate characterising the driving liquidity risk. In contrast to the credit risk literature, the intensities and loss rates are calibrated simultaneously and results show that loss rates display more variations than intensities. Another advantage of our modelling approach, compared to the ad–hoc modelling approach adopted by practitioners, is that our model is motivated by the driving risk of market anomalies. It is hence more explanatory and consistent with market fundamentals. In order to account for potential randomness, we also set up stochastic models for the intensity and the loss rate. We show that under certain conditions closed form solutions exist, which can be used to tractably calibrate or estimate the model parameters.