

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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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

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Contents

Abstract	xii
1 Introduction	1
1.1 Background and Motivation	1
1.2 Thesis Contents	6
2 Literature Review	8
2.1 Introduction	8
2.2 Ad-hoc Approach	8
2.2.1 No Arbitrage Relationship Before and After the Crisis	9
2.2.2 Mercurio (2010)	14
2.2.3 Bianchetti (2010)	15
2.2.4 Henrard (2007, 2010)	18
2.2.5 Fujii et al. (2009)	18
2.3 Fundamental Approach	20
2.3.1 Default Risk	20
2.3.2 Liquidity Risk	24

2.4	Uncovered Interest Parity Puzzle	31
3	On the Behavior of the Cross–Currency Swap Basis: Empirical Observations Before and During the Recent Financial Crises	35
3.1	Introduction	35
3.2	No-Arbitrage Bounds	38
3.2.1	Bounds for FX Forward Rates	38
3.2.2	Bounds for Basis of Currency Swaps	41
3.3	Data and Methodology	46
3.3.1	Description of Data	46
3.3.2	Methodology	48
3.4	Results	53
3.4.1	Forward Exchange Rate	53
3.4.2	Currency Swap Basis Rates	58
3.4.3	Exploit Violations	62
3.4.4	Making Sense of Violations	63
3.4.5	Limits to Arbitrage	65
3.5	Conclusion	66
4	Carry Trade and Liquidity Risk: Evidence from Forward and Currency Swap Markets	67
4.1	Introduction	67
4.2	Data	70
4.2.1	FX Option Pricing Formula	71

4.2.2	FX Volatility Smile	73
4.3	Empirical Methodology	78
4.3.1	Specifications of Model Variables	78
4.3.2	Econometric Model	80
4.3.3	Panel Regression	82
4.4	Results	85
4.4.1	Principal Component Analysis	85
4.4.2	Summary Statistics	85
4.4.3	Unit Root Tests	90
4.4.4	Factor Model Regression Results	90
4.4.5	Panel Regression Results	97
4.4.6	Robustness Check	100
4.5	Conclusion	100
5	A Consistent Framework for Modelling Spreads in Tenor Basis Swaps	102
5.1	Introduction	102
5.2	Model Set-up and Implementation	104
5.2.1	Liquidity risk, Basis Spreads and Limits to Arbitrage	104
5.2.2	Model and Implementation	106
5.3	Data, Methodologies and Results	111
5.3.1	Construction of OIS Discount Factors	111
5.3.2	Bootstrap Liquidity Spreads	115
5.3.3	Analytical Analyses	118
5.3.4	Global Optimization	122

5.3.5	Optimisation Results	126
5.4	Conclusion	128
6	Parsimonious Modelling of Intensity and Loss Rate	130
6.1	Introduction	130
6.2	Model Set-up	133
6.3	Optimization Scheme	135
6.3.1	Optimization Constraints	135
6.3.2	Initial Values	138
6.4	Results	139
6.5	A Stochastic Model	149
6.6	Conclusion	156
7	Conclusion	157
A	Proof of Equation (2.7)	160
B	Proof of Equation (4.9)	164
C	Principal Component Analysis	166
D	Chow Breakpoint Test Results	169
E	Time-Inhomogeneous Poisson Process	170
F	Proof of Equation (6.5), (6.6), (6.7) and (6.8)	173
G	Cox Process	175

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.