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David F. DeRosa

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For Julia DeRosa

Preface

It is well known that foreign exchange is the world's largest financial market. What is less well known is that the market for currency options and other derivatives on foreign exchange is also massively large and still growing. Currency options are less visible than options on other financial instruments because they trade in the main in the private interbank market. Sadly, the field of foreign exchange is not popular with authors of technical business books. The attention that is given to foreign exchange pales in comparison to the vast outpouring of books on the bond and stock markets.

This book has been written for end-users of currency options, newcomers to the field of foreign exchange, and university students. I employ the real-world terminology of the foreign exchange market whenever possible so that readers can make a smooth transition from the text to actual market practice.

I use this book as the textbook for a course entitled "Foreign Exchange and Its Related Derivative Instruments" that I teach in the IEOR department of the Fu Foundation School of Engineering and Applied Science at Columbia University. I taught forerunners of this course (using the previous editions) at the Yale School of Management and University of Chicago's Booth School of Business. Students may be interested in a companion volume to this book that I edited for John Wiley & Sons. That book, *Currency Derivatives,* is a collection of scientific articles that have had an important impact on the development of the market for derivatives on foreign exchange.

This is the third edition of *Options on Foreign Exchange*. The foreign exchange market has undergone major transformations since the first edition came out in 1992 and this is especially the case since the second appeared in 2000. During the decade of 2000–2010 one could say there has been at least three remarkable developments in the foreign exchange market, each of which is has been incorporated in this new edition. The first is that the size of the foreign exchange market has grown enormously; by one count \$4 trillion of foreign exchange changed hands in a day in 2010 (compared to \$1.2 trillion in 2001). A substantial portion of this growth has to be ascribed to the success of electronic trading platforms and computerized dealing networks. Second, market stresses during the turmoil of 2007–2008 revealed anomalies in the foreign exchange market, both in the forward market and in the market for options on foreign exchange. Third, these abnormal market conditions have been the impetus for acceleration in the development in new and advanced option models.

WHAT'S NEW TO THIS EDITION

This edition has a substantial amount of new material, mostly included in reaction to market experience and the general development in the theoretical and applied understanding of currency options.

I have included new discussions of the volatility surface and the Vanna-Volga method. There are also new sections on static replication, numerical methods, and advanced models (stochastic and local volatility varieties). The materials on barrier, binary, and other exotic options are greatly expanded. There are a great number of new numerical examples in this edition.

BEFORE YOU BEGIN

I am fairly certain that nobody can become fully versed in the topics of currency options without becoming involved in the market. This book offers the next best thing. To that end it is important to start out learning about these products in the context of correct market terminology and protocol. That is why I always attempt to introduce and use trading room vernacular in this book. On the other hand, a certain level of mathematical understanding is also required. Some math is unavoidable, but its level of difficulty is easily overestimated. True enough, there a lot of equations in this book. However most of the important concepts can be grasped with little more than working knowledge of algebra and elementary calculus.

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Contents

CHAPTER 1

Foreign Exchange Basics

I start with some basic knowledge about foreign exchange that the reader will want to have before tackling currency options.

THE FOREIGN EXCHANGE MARKET

An exchange rate is a market price at which one currency can be exchanged for another. Exchange rates are sometimes called pairs because there are always two currencies involved. If the exchange rate for Japanese yen in terms of U.S. dollars is 90.00, it is meant that yen can be traded for dollars—or dollars traded for yen—at the rate of $1 for 90.00 yen.

A spot foreign exchange transaction (or deal)[1] is an agreement to exchange sums of currencies, usually in two bank business days' time. This transaction is the core of the foreign exchange market. A forward transaction is a deal done for settlement, or value, at a time beyond spot value day. There are two kinds of forwards. Forward outrights are similar to spot deals. The exchange rate is agreed when the deal is done on the trade date, but currencies settle at times in the future further out on the settlement calendar, say in a week, or a month, or in many months. A forward swap is the combination of a spot deal and a forward deal done in opposite directions. Forward outrights and forward swaps will be covered in detail later in this chapter.

It is well known that the foreign exchange market is a very large market, but exactly how large is hard to say. Our single best source as to the size and structure of the worldwide foreign exchange market is an extensive survey of trading done by the Bank for International Settlements (BIS) in

[1]Legal definitions of the vocabulary of foreign exchange dealing can be found in International Swaps and Derivatives Association, Inc. (1998).

conjunction with the central banks of 50 or so nations.[2] The most recent survey, published in 2010 (BIS 2010), documented the virtual explosion in foreign exchange trading since the previous surveys done in 2007, 2004, and 2001. After adjustments for double counting,[3] $4 trillion of foreign exchange changed hands per day in April 2010 compared to $3.3 trillion, $1.9 trillion, and $1.2 trillion in April of 2007, 2004, and 2001, respectively. These statistics cover transactions in spot, forward outright, forward swaps, currency swaps, and options (Exhibit 1.1).[4] There are at least two other recent central-bank-sponsored surveys covering specific segments of the foreign exchange market, both dating from October 2009. A Bank of England survey[5] of the London market (BOE 2009) estimated $1,430 billion in total daily turnover (including spot, outright forwards, non-deliverable forwards, and foreign exchange swaps). A Federal Reserve Bank of New York (NYFED 2009) survey[6] of the New York market estimated $679 billion of trading the same instruments.

Foreign exchange trading is done practically everywhere there is a banking center. According to the BIS 2010 survey, the largest centers by share of total world turnover were the United Kingdom (37 percent), the United States (18 percent), Japan (6 percent), Singapore (5 percent), Switzerland (5 percent), Hong Kong (5 percent), and Australia (4 percent). Not to be forgotten are the emerging markets nations where recently published data (BIS; Mihaljek and Packer 2010) (Exhibit 1.1) show to be rapidly expanding centers for foreign exchange trading.

There are well more than 100 currencies. As a general rule practically every country has its own currency[7] (with the European countries in the

[2]The practical reality is that the BIS and the central banks are in a unique position to accumulate such information because foreign exchange is an over-the-counter market that is conducted by commercial banks around the world. Unlike equities, for example, there is no central "tape" where trades are publicly posted.

[3]Every trade involves two counterparties. The BIS survey adjusts for double counting, meaning that a trade counts only once. For example, suppose Bank A buys 100 million dollar/yen from Bank B. Adjusting for double counting means that this would be counted as a single trade of 100 million of dollar/yen.

[4]For comparison, BIS (2010) reports that turnover in interest rate forward rate agreements and interest rate swaps were $600 billion and $1,275 billion, respectively in 2010.

[5]The Bank of England (BOE 2009) sponsored the Foreign Exchange Joint Standing Committee's survey of 31 institutions active in the foreign exchange market.

[6]The Federal Reserve Bank of New York (NYFED 2009) sponsored the Foreign Exchange Committee's survey of 25 participating institutions.

[7]See DeRosa (2009).

	Total Global Turnover (1)					Turnover in Emerging Markets (2)		
	1998	2001	2004	2007	2010	2004	2007	2010
Spot transactions	568	386	631	1,005	1,490	119	188	203
Outright forwards	128	130	209	362	475	21	47	73
Foreign exchange swaps	734	656	954	1,714	1,765	125	231	277
Currency swaps	10	7	21	31	43	3	4	7
Options and other products	87	60	119	212	207	10	18	24
Total	1,527	1,239	1,934	3,324	3,981	279	489	585
Memo: Turnover at April 2010 Exchange Rates	1,705	1,505	2,040	3,370	3,981			
Exchange-traded derivatives	11	12	26	80	168			
Global turnover by counterparty								
With reporting dealers	961	719	1,018	1,392	1,548			
With other financial institutions	299	346	634	1,339	1,900			
With non-financial customers	266	174	276	593	533			

EXHIBIT 1.1 Global Foreign Exchange Market Turnover (Daily Averages in April, in Billions of U.S. Dollars)
Source: (1) BIS (2010) and (2) Mihaljek and Packer (2010).

euro zone being a prominent, but not unique, exception). Yet trading in the foreign exchange market is remarkably concentrated in a handful of exchange rates (Exhibit 1.2). What is noteworthy is that the sum of trading in the dollar against the euro, yen, and sterling (in order of volume) made up 51 percent of all foreign exchange trading in 2010. In one sense, the foreign exchange market is largely the price of the dollar, inasmuch as in 2010 the dollar was on one side of 84.9 percent of all trades[8,9] (followed by the euro (39.1 percent), the yen (19.0 percent), sterling (12.9 percent), and the Australian dollar (7.6 percent).[10] But even a currency with a small share of total turnover can have a large volume of trading because the overall size of the market is enormous.

Foreign exchange dealing has become steadily more concentrated among a handful of powerful dealing banks. Indeed, according to the BIS, the top five dealers captured more than 55 percent of the market by 2009, up from a little more than 25 percent in 1999 (see Gallardo and Heath 2009).[11] At the same time that trading in foreign exchange has been growing, the number of banks doing large-scale foreign exchange trading has been shrinking. Roughly speaking, the number of money center banks that account for 75 percent of foreign exchange turnover has roughly dropped by two-thirds in the period between 1998 and 2010 (BIS 2010). On a geographic basis, the number of such banks shrunk from 24 to 9 in the U.K., from 20 to 7 in the United States, from 7 to 2 in Switzerland, from 19 to 8 in Japan, and from 23 to 10 in Singapore during this decade. This is probably best seen as an outcome of the general trend of consolidation in the financial services industry. In the meantime the development of electronic trading has materially altered the nature of the foreign exchange market. The lower section of Exhibit 1.1 shows global foreign exchange turnover by counterparty to the reporting banks. Note that the historical pattern is for dealing banks

[8] The percentage share of the dollar was 85.6 and 88.0 in the 2007 and 2004 surveys, respectively.

[9] The BIS (2007) survey addressed the question of the euro's challenge to the dollar's dominance: "Expectations that the euro might challenge the U.S. dollar's dominance in the FX market have not been borne out. While dollar/euro remained the most important currency pair traded, accounting for 27% of total turnover measured in notional amounts, only 8% of all trades involved the euro and a currency other than the dollar" (page 15).

[10] The BIS (2007) survey estimated that 23 emerging-markets currencies tracked in the survey were 19.8 percent and 15.4 percent of trading in 2007 and 2004, respectively.

[11] Gallardo and Heath (2009) present a graph from which I have taken approximate numbers as to degree of concentration of foreign exchange dealing. See their Graph 1, left-hand Panel, their page 85.

EXHIBIT 1.2 Reported Foreign Exchange Market Turnover by Currency Pair (Daily Averages in April, in Billions of U.S. Dollars and Percent)

	2001		2004		2007		2010	
	Amount	% Share	Amount	% Share	Amount	% Share	Amount	% Share
U.S. dollar/euro	372	30%	541	28%	892	27%	1101	28%
U.S. dollar/yen	250	20%	328	17%	438	13%	568	14%
Sterling/U.S. dollar	129	10%	259	13%	384	12%	360	9%
Australian dollar/U.S. dollar	51	4%	107	6%	185	6%	249	6%
U.S. dollar/Swiss franc	59	5%	83	4%	151	5%	168	4%
U.S. dollar/Canadian dollar	54	4%	77	4%	126	4%	182	5%
U.S. dollar/Swedish krona	6	0%	7	0%	57	2%	45	1%
U.S. dollar/Other	193	16%	300	16%	612	18%	705	18%
Euro/yen	36	3%	61	3%	86	3%	111	3%
Euro/Sterling	27	2%	47	2%	69	2%	109	3%
Euro/Swiss franc	13	1%	30	2%	62	2%	72	2%
Euro/other	22	2%	44	2%	123	4%	162	4%
Other currency pairs	28	2%	50	3%	139	4%	149	4%
All currency pairs	1,239	101%	1,934	100%	3,324	100%	3,981	100%

Source: BIS (2010).