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Incorporating Derivative Order Flow In Foreign Exchange Microstructure Theory

Kieran Condon
The University of Cape Town

November 2008

Abstract

This paper justifies the claim that orders on exchange rate derivatives, including forwards, swaps and options, have a place in exchange rate determination. A simple option model based on Kyle (1985) is presented illustrating that option order flow informs traders about expectations of future exchange rates. The model is placed in a complete market where options are replicable thus conveying the same information as spot orders. A proposal is made that forward order flow has a variable impact on spot rates, depending on the extent to which they are used in hedging activities and must be treated separately to spot orders. Finally, the construction of FX swap order flow could be achieved by considering only the spot leg of the swap transaction as the forward leg in a swap is necessarily a hedging tool with no effect on rates.

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1 Introduction

Whilst spot order flow has become an increasingly popular tool in foreign exchange rate determination, derivative order flow¹ has been largely overlooked. Orders for Foreign Currency Derivatives such as forwards, FX swaps and options can inform the market about the future value of exchange rates.² Derivatives are relevant to foreign exchange microstructure, the field dealing in order flow, as the majority of trade in currencies, 70%, occurs in derivatives (Bank of International Settlements, 2007). This paper deals with the extension of traditional microstructure theories of order flow to include foreign currency derivatives. The purpose is to justify the validity of derivative order flow and encourage this field of research. I offer the following primary findings:

- Option orders contain private information about the future value of the exchange rate as displayed in a model of European call option order flow based on Kyle (1985).

This simple model predicts that call orders carry the same information as spot orders when in a complete market and can be used similarly in updating our expectations of exchange rates. A framework is presented which displays informational flows from option orders to exchange rates. The model differs from others in that it does not infer a preference for informed investors to utilize derivative instruments (Easley, O'Hara & Srinivas, 1998) nor does it rely on assumptions of incomplete markets (Back, 1993; Rzepkowski, 2003) in which option order flow carries unique (non-redundant) information on the exchange rate and is used to supplement traditional spot order flow. In this paper any redundancy is ignored, as, although option order flow is equivalent to spot order flow, it may be more accessible to certain financial institutions. Options on currencies represent one of the fastest growing segments of the foreign exchange market and derivative trades in general significantly outweigh those of spot trades (Bank of International Settlements, 2007).

¹This may be the first usage of the term 'derivative order flow'. It is defined as an aggregation of orders (transaction volume) for derivative contracts, signed positively for a purchase and negatively for a sale with respect to the initiator of the transaction.

²An exhaustive list of literature addressing derivative order flow includes Back (1993), Rzepkowski (2003) and Easley, O'Hara & Srinivas (1998). These papers address only option order flow, and only the last does so empirically. Froot & Ramadorai (2002), Bjønnes, Rime & Solheim (2004), Evans & Lyons (2005) and Gereben, Gyomai & Kiss (2006) include forward orders in their traditional spot order flow data. Only the last justifies or discusses this usage whilst the others do so almost without mention.

Both spot and derivative orders have a variable impact on exchange rates depending on the extent to which they are used in hedging activities. Forwards represent a popular tool in hedging foreign exchange exposure and when used as such they will have no effect on exchange rates (Gereben, Gyomai & Kiss, 2006). Forward order flow has been utilized informally in microstructure; most typically it is aggregated with spot orders (Bjønnes, Rime & Solheim, 2004; Evans & Lyons, 2005). This assumes that forward orders reflect on spot prices in the same way that spot orders do.

I propose through a review of available literature that:

- There are differences in the extent to which investors use forward orders and spot orders to hedge, thus the information they convey is likely to differ. As such forwards must not be aggregated with spot orders to construct order flow data.

Finally, orders for FX swaps, in which the majority of foreign currency transactions occur, do drive spot rates although there is currently no room in microstructure theory for them to do so; as a contract of both a spot and counter-veiling forward trade, the resultant order flow is zero. I argue that:

- FX swaps can be incorporated, by considering only the spot leg of the swap transaction. This is justified as the forward leg is necessarily a hedging tool with no effect on the exchange rate. The principles of the Interest Rate Parity Theorem similarly confirm that only the spot transaction bears on the spot rate (Saunders & Cornett, 2005).

This does not mean one should use only spot order flow. The spot leg of a swap transaction is unique to a spot order; the two are recorded separately by the Bank of International Settlements and by central banks. Papers that use spot data are not considering the spot leg of swap agreements and exclude more than half of all foreign exchange transactions.

The structure of the paper presents these topics in the order presented above. In order to set the background, section 2 continues with a discussion of traditional microstructure models that is necessary in addressing derivative order flow (in particular, Kyle 1985 and Evans & Lyons 2002a). Section 3 follows with a justification for derivative order flow, showing that derivative orders display

characteristics of information-revelation and inventory-control, forces which are responsible for price effects in the traditional spot models. Section 4 describes the foreign exchange market, its size and structure and section 5 presents the first primary finding on option orders. The following sections, 6 and 7, addressing forwards and swaps do not present results based on empirics, yet do present original proposals through evidence constructed in a review of available literature.

2 Foreign Exchange Microstructure

Exchange rate order flow is a measure of actual customer orders for exchange rates, observed moment by moment by the dealers who set rates. These individual orders are signed from the perspective of the initiator to the trade and aggregated, usually into daily order flow. Thus, an overall positive order flow indicates net purchasing activity by customers during a day. Observing order flow offers a direct insight into the market and those willing to back their beliefs with cash. This private information has been for many years difficult for any non-dealer to access, and so, the research is relatively new.

The classical approach to exchange rates focuses on fundamentals in the macroeconomy. It deals with the way exchange rates are affected by interest rates, money supplies and trade balances. Although this is intuitive it suffers from assuming that there is a uniform mapping between these variables and the exchange rate. It also assumes information about fundamentals is publicly known.³ The microstructure approach posits that not all news relevant to exchange rates is publicly known, not all market participants interpret news uniformly and trading mechanisms can differ in ways that affect price (Lyons, 2001). However, private information and customer sentiment can be determined; it is quite clearly displayed in the accumulation of customer orders on the screens of currency dealers.

Information in microstructure is, paradoxically, of a macroeconomic nature. Fundamental variables are drivers of the exchange rate. In the traditional micro models, information about fundamentals is first transformed into order flow,

³This thesis will avoid the well-documented debate over the classical approach. Nevertheless, it is worth looking at why the debate exists (Meese & Rogoff, 1983; Engel & West, 2004). Spot price movements appear to be determined to a large extent by the order flow process and hardly at all by the classical approach (Evans & Lyons, 2002a)

it then becomes a signal to price setters. In more recent hybrid models, in particular those used in empirical analysis, both the classical approach and the traditional micro approach are accommodated. Fundamentals can affect price directly or through order flow. With models that allow for both, the data can determine their relative importance (Lyons, 2001).

Order flow is a variant of the term excess demand, although it is unique.⁴ As expected, a buy order for an exchange rate leads to an increase in its price. There are two different branches of microstructure to explain this result, namely inventory-control and information-revelation models. The first relies on the risk-averse nature of currency dealers. When customers exhibit buying behaviour for a foreign currency, dealers are compelled to raise its price so as to attract sellers. This ensures the dealer does not carry the risk of foreign exchange exposure. In this sense they are controlling their inventory of foreign exchange so as to maintain a zero balance. In reality, dealers in foreign exchange do attempt to close out their positions before the end of each day and hedge their exposure (Lyons, 1993).

Information-revelation models assume there are individuals in the market with private information about the future value of the currency. Buy orders signal the belief by informed investors in a future appreciation. Given what they know, if they are willing to purchase the currency at the current price, it is undervalued. Dealers adjust prices upwards accordingly.

The Evans & Lyons (2002a), three-stage model is put to use in a large portion of empirical papers on microstructure. It is worth explaining its design, as it will be discussed regularly in the paper. It is interesting to note how the framework of the model is somewhat true-to-life; it looks at the day-by-day operations of dealers in the market. A typical characteristic of microstructure modeling is the simulation of how real foreign exchange markets operate.

The model is inherently an inventory-control one. Nevertheless there is room for customers to trade with private information. There are multiple currency dealers in the market, each with their own set of customers. A public signal is realized at the beginning of the day, visible to the price setting dealers. This is the payoff of holding foreign exchange, as determined by fundamental variables, such as interest rates, and it directly affects the price quoted. The customers

⁴Order flow represents actual orders for an asset, while excess demand represents merely a willingness to buy or sell. The former allows for passive demand and supply through a marketmaker.

place orders with their dealers following a common price announcement in the market. Private information is embedded in these trades, allowing dealers the opportunity to observe the actions and the sentiment of a segment of the market. These 'round one' order flows are visible only to dealers with which they were enacted. They are not publicly observable.

Dealers partake in 'round two' inter-dealer trading. Their risk aversion compels them to reverse the orders they took part in during round one. If their customers were net purchasers, they will purchase the same magnitude of foreign exchange in the inter-dealer market. At the end of the second round all dealers observe the net inter-dealer order flow, the sum of dealer-to-dealer trades and thus a function of round one customer trades. Through this there is information agglomeration; customer trades can be imputed by the efforts of their dealers to counterbalance them; dealers are able to 'observe' the actions of other dealers' customers. This round was one of sharing dealer risk. Dealers each still hold a net imbalance shared between them. A third round occurs at the end of the day to afford dealers the opportunity to eliminate their overnight exposure entirely.

Customers are encouraged into the third round to eliminate dealer imbalances. This is done by an increase or a decrease in the price of the foreign exchange. Net buying activity in round one would warrant an increase in price to attract sellers in round three. Accordingly, third round orders are equal to but opposite in sign of first round orders and aggregate customer order flow cancels itself out. Customers in the third round are termed liquidity traders and are on the 'pull side' of prices (Bjønnes, Rime & Solheim, 2004). They provide liquidity to the market when it is needed. Customers of round one are termed speculators or aggressors and are on the 'push side'; they induce price changes. The model does not require that these two groups be different segments of society or the same, merely that there are customers willing to be aggressors or liquidity providers in the respective rounds.

It is possible to utilize either inter-dealer order flow or customer order flow in empirics. Both are linearly related and are able to depict the net buying or selling behaviour of customers. Applying customer order flow, however, is non-trivial. It requires separating first round and third round orders, which by definition cancel each other out. Therefore, empirics do require that these market segments be defined. In practice the distinction is often drawn between financial and non-financial participants or foreign and domestic participants (Bjønnes, Rime & Solheim, 2004; Gereben, Gyomai & Kiss, 2006). I later argue

that the distinction can be drawn between spot and forward trading participants, where the latter represents the pull side.

A far earlier model is that of Kyle (1985). It focuses on information-revelation. There is one informed investor in the market, one dealer and a multitude of uninformed traders. The dealer is responsible for setting price, and does so in order to protect himself from informed trades. The dealer also provides liquidity to the market. Gereben, Gyomai & Kiss (2006) provide an intuitive interpretation of this model. As the dealer is both a price setter and liquidity provider, he is in some way a representation of the dealers and pull side customers in Evans and Lyons (2002a). The customers in Kyle (1985) are then a representation of the push side of the market. This allows one to interpret an exchange rate response to customer order flow as either a result of inventory-control or information-revelation.

Microstructure theories are becoming popular amongst dealers. They use it not necessarily in forecasting, but in being aware that customer order flow is informative. Cheung & Chinn (2001) find that in a sample of 400 traders from Hong Kong, Tokyo and Singapore, 25% did so on the basis of customer order flow rather than through technical analysis, fundamentals or to earn on spreads.⁵ The large level of volatility in the Yen/Dollar exchange rate, which occurred in 1998, is attributed to dealers reacting to portfolio shifts observed through order flow (Cai et al, 2001).

3 A Justification for Derivative Order Flow

Literature on derivative microstructure is scarce.⁶ Gereben, Gyomai and Kiss (2006) are the only authors to utilize a separate variable for forward order flow and examine its coefficient.

Options are addressed in the discussions of Back (1993), Easley, O'Hara & Srinivas (1998) and Rzepkowski (2003). The first and last are solely theoretical in nature. Neither a theoretical nor empirical analysis of FX swap order flow exists.

⁵Reference through Cai et al (2001)

⁶Froot & Ramadorai, 2002; Bjønnes, Rime & Solheim, 2004; Evans & Lyons 2005; Gereben, Gyomai & Kiss, 2006

Despite this there is an abundance of research outside of microstructure looking into how derivatives impact on the underlying price of an asset. The basis for this is the existence of incomplete markets. A complete market framework commonly assumes that investors are rational and share the same information (although these assumptions do not, in themselves, define a complete market). New information is factored into the price of financial instruments immediately. In addition there are no transaction costs. These requirements preclude arbitrage opportunities in the market and price movements between derivatives and underlying assets are simultaneous (Deutsche Bundesbank, 2006). When these requirements are not met derivatives can affect the price level and price volatility of underlying assets (Detemple & Selden, 1991).

Research on derivatives and their effect on asset prices falls into the two categories of Direct-effect models⁷ and Feedback models. These can be likened to the two ways in which spot order flow affects price; through information revelation and through inventory control of dealers. Direct-effect models and Feedback models could be described respectively as information-revelation and inventory control models as well. They do not utilize order flow and cannot be defined as microstructure, yet their conclusions support the notion that derivative order flow affects price in the same manner that spot order flow does.

Considering information-revelation, information about the spot price can be revealed in derivative trades. Buying a call or selling a put are trades that benefit from a stock price increase. When there are informed investors in the market willing to hold these contracts, the trades carry positive information about future asset prices. Similarly, selling a call or buying a put carries negative information about future stock prices (Easley, O'Hara & Srinivas; 1998).

Information revelation in derivative markets may precede those in spot markets when informed investors prefer to deal in derivatives rather than underlying assets (Deutsche Bundesbank, 2006). Reasons for informed investors to prefer derivatives include the ability to leverage the price movement of the underlying with a small capital outlay in derivatives. One can implement complex strategies through trade in a single derivative that replicates the payoffs of many assets.

Derivatives can increase the benefit of obtaining information by increasing the number of investment opportunities (Cao, 1999). This leads to greater levels of

⁷I have provided this definition for lack of a general name. The term 'Direct-effect' is used to counterpoint the term 'Feedback'.

information acquisition by all. When informed investors acquire more precise private signals (through the availability of derivatives) the overall risk of the underlying goes down and its price increases. In addition, underlying price volatility is reduced as better-informed investors are less surprised by public information announcements.

If a derivative security is replaced in a market by a synthetic one, the loss of the derivative results in the loss of important information (Grossman, 1988). For example, portfolio insurance involves the purchase of a put, the right to sell an asset, in case of a future depreciation. Puts can be replicated by a holding of cash and futures. If this 'synthesized' security replaces puts the market no longer has access to put prices. A high put price indicates a large number of investors with a strategy such as, "sell assets if their value falls below 25%." They therefore inform us now about the fraction of people ready to leave the market in the future. Without puts the underlying assets future price volatility can rise because of a current lack of information about the hedging activities that are in place.⁸

Grossman (1988, pg 278) considers the information in derivative prices but not in derivative orders. Yet his thesis has parallels with microstructure, "The existence of a traded security (derivative) will aggregate information regarding future trading plans which is currently dispersed among investors." Microstructure models describe the aggregation of dispersed information through the observation of order flow.

The above direct-effect models all support that information-revelation occurs through the trade in derivatives and through their observation by market participants. Feedback models deal with 'information-free' trading (Deutsche Bundesbank, 2006). These models can be likened to inventory-control models of microstructure; trade in derivatives induces inventory-control behaviour (where a trader minimizes foreign exchange exposure) in the form of delta hedging. Specifically, the models focus on the effect dynamic hedging of option positions has on the underlying asset. The replication of a derivative has no effect on spot prices in complete markets, but the trade on the spot market needed to hedge the derivative does. One holds the underlying asset to neutralize the delta of the derivative. Dynamic hedging, maintaining a perfect hedge over time, is

⁸Grossman's paper was published only two years after the Dow Jones Crash of 1987 where many people blamed portfolio insurers for inciting sell strategies. Instead of buying puts, they were synthesized through the short selling of equity and index futures (Hull, 2005)

attributed in some models with a resulting upward push on underlying asset volatilities (Frey & Stremme, 1997).

Feedback effects have been applied to Derivative Order Flow as described by Rzepkowski (2003). Risk-averse dealers in foreign exchange who are unwilling to hold overnight positions attempt to offset their exposure before the end of the day. The spot market does this as in the typical three-stage Evans and Lyons model; dealers set a price so as to sell/purchase 'spot' imbalances back to customers. As such it is an example of an inventory-control model. In the call market, dealers do not sell surplus options back to the market, they embark on a delta-hedging strategy which involves buying or selling an amount of the underlying currency. Ultimately, the spot market is affected by risk-averse dealers in both the spot and options markets.

Derivatives carry implications for spot prices. They do so through the same channels that traditional order flow does, namely through information revelation and inventory control. This is true too in Derivative Microstructure models such as Back (1993), Rzepkowski (2003) and the model to be presented below.

The following section describes the market that microstructure theory simulates; namely the real dealers, customers and trading floors where foreign exchange transactions take place. This gives context to the model of call orders which follows and is presented for this purpose. In addition, I intend to make explicit the gap in traditional theory that is being filled, considering that turnover in derivative markets far outweighs that in spot markets.

4 Foreign Exchange Spot and Derivative Markets

Turnover in the foreign exchange market is enormous and the greatest number of trades are in derivative products. In April 2007 global foreign exchange transactions averaged \$3.3 trillion per day (Bank of International Settlements, 2007). Spot trades, which occur by definition within 2 days, amount to \$1 trillion. The majority, \$2.3 trillion, is made up by the derivatives market, dominated by foreign exchange swaps (see table below).⁹ In the last three years growth in foreign exchange has taken off as depicted in the second last column. Overall

⁹Foreign exchange swaps involve two legs to the transaction. A spot trade is made for a currency whilst an offsetting forward agreement is entered into simultaneously. This differs from a currency swap, involving the exchange of interest payments denominated in different currencies.

daily trades have increased by 74% since 2004. The biggest growth areas are FX swaps and options with growth in turnover within the period of 81.6% and 81.2% respectively. Spot trades grew at a slower pace.

Global OTC Foreign Exchange Turnover

Daily Averages in April, in billions of US dollars

	1992	1995	1998	2001	2004	%incr.	2007
Spots	394	494	568	387	621	61.8	1005
Derivatives	382	643	959	854	1290	79.8	2320
<i>Forwards</i>	58	97	128	131	208	74	362
<i>FX Swaps</i>	324	546	734	656	944	81.6	1714
<i>Currency Swaps</i>			10	7	21	52.4	32
<i>Options</i>			87	60	117	81.2	212
Total	776	1137	1527	1241	1911	74	3325

Bank of International Settlements, 2007

Currencies and Foreign Currency Derivatives (FCDs) can be traded 24 hours a day except on weekends and holidays and trades occur in a decentralized worldwide marketplace. The market for FCDs began with other derivatives in the 1970s in Chicago, London and Philadelphia where listed futures, calls and puts could be found (DeRosa, 1998). Dealers were primarily floor traders and specialty shops. Since then most of the market for currency derivatives has moved into major commercial banks where most of the spot foreign exchange market operates. Citibank, Deutsche Bank, UBS AG, Bank of America and Barclays Capital are primary examples. These major dealers had some advantages in derivatives trading that facilitated this move. DeRosa (1998) outlines technical expertise, specialized staff and investments in risk technology as strengths of the banks. Large dealers benefit over their smaller counterparts because it is cheaper and less time consuming to hedge a large portfolio; many of the positions in the book offset each other and provide counter-veiling movements in delta. Additionally, proximity to the spot market aids derivative trading as it allows for easier delta hedging through purchases of the underlying.

Customers of foreign exchange are made up of the non-financial sector and the non-dealer financial sector. Financial customers include banks, mutual funds,

pension funds and hedge funds. Non-financial customers have businesses requiring foreign exchange transactions; those involved in trade and foreign investment for instance. Allayannis & Weston (2001) find that out of a sample of 720 US, non-financial companies with assets worth more than \$500 million as early as the period between 1990 and 1995, approximately 37% used foreign currency derivatives. The exporting proportion of this group had a higher percentage of FCD usage at 60%. Geczy et al (1997) found that of the 372 non-financial Fortune 500 companies in 1990, 41% had used a currency derivative such as a swap, forward or option.

Most of forex trade occurs between the large banks in what is known as the inter-bank market; inter-dealer trade to theoreticians. According to the BIS report (2007), the growth in inter-bank transactions increased proportionately to previous years but was far outstripped by the growth in dealer trades with customers. Nevertheless inter-dealer trades still dominate. 43% of traditional foreign exchange occurred between reporting dealers in 2007, down from 53% in 2004. 40% occurred between a reporting dealer and non-reporting financial institutions and 17% occurred between dealers and non-financial customers.

5 A Model of Call Order Flow

The following model is an example of information-revelation in derivative order flow. It follows closely the model of Kyle (1985) where spot orders for an asset cause dealers to adjust prices accordingly, yet alters it to deal in European call option orders alone.

The model is a single auction equilibrium and does not include sequential or continuous trades as seen in Kyle (1985). It reveals the flow of information from order flow of the derivative to the expectations of market makers about spot exchange rates through the following two outcomes:

The expected value of S_T , the value of the underlying currency at the end of the call contract, is related positively to order flow of call options. Therefore, as more customers buy calls on the currency the expected value of the currency rises for the market maker who deals the options and observes the order flow.

The variance of S_T , conditioning on the information given by order flow, is lower than the variance of S_T before receiving order flow.

The model achieves a simple justification for the consideration of options in order flow analyses. It differs from alternative models in that it ignores a discussion on the redundancy of derivative assets in complete markets. There are benefits and costs to such an approach; the overall justification is that it focuses on the possibility of extracting information from option trades which are numerous in the market and growing in prevalence. This would benefit any institution with greater access to option rather than spot orders.

It also assumes away the need for more complicated data, including structural characteristics of the option such as delta, as required in incomplete markets. Rzepkowski (2003), based in incomplete markets, concludes that there is a non-linear relationship between call orders and rates dependant on these characteristics. Back (1993) uses a similar model to the one below, although it includes trade in the underlying asset, to show that through the presence of traded derivatives, the market is inherently incomplete. These papers outline the weakness of my approach, the information derived from options is only comparable to spot orders when markets are complete and indeed that may not be the reality. This is discussed further at the end of the section.

5.1 Model Assumptions

5.1.1 Participants

In this framework, three types of participants trade European Call Options. These are a single informed trader, I , many uninformed traders, U and a market maker, M . The informed has full knowledge of the final value of the currency underlying the call option. Time is measured from the beginning of the call contract until its expiry at time T .

5.1.2 Orders

Trading takes place over two steps. In the first, the informed trader and the uninformed traders simultaneously decide the quantity of call options they will trade, placing orders for these quantities with the market maker. The uninformed can be termed noise or liquidity traders and they trade randomly with orders following a normal distribution. They enter the call market in order to hedge their asset and liabilities which are exposed to a varying degree to the

currency and its final value, S_T . The quantity of options traded by the informed is denoted i . The quantity of options traded by the uninformed is denoted e and is distributed normally, $e \sim N(0, \sigma_e^2)$. The sum of e and i is market order flow, $d = e + i$.

5.1.3 Information

The informed trader chooses their order i in order to maximize profits based on full knowledge of the final value of the currency. The uninformed are only aware that the final value of the currency is distributed normally as, $S_T \sim N(0, \sigma_S^2)$. The random variables S_T and e are independently distributed.

The orders of the informed are indistinguishable from the uninformed so they are disguised from the market maker. This prevents the market maker from conditioning solely on informed orders, which would eliminate the ability of the informed to make profits. In addition, both informed and uninformed traders are unaware of each other's actions.

5.1.4 Player's Behaviour

The informed trader sets i so as to maximize profit given their knowledge of the final value of the currency. The market maker sets the strike price, K , so as to earn zero profits due to free entry of competing market makers.

The market maker, upon receiving order flow d , sets the strike price of the options sold. This is a departure from the usual case, typically option writers choose a premium and offer a range of strike prices, hedging their positions through investments in other assets.

In this framework there is a fixed premium of zero through the zero profit under free entry condition and it is reasonable to imagine a market maker setting the strike instead. With a zero premium, the writer is more exposed to foreign exchange risk; option contracts represent a zero-sum game. They reserve the right to offer a single strike they calculate will avoid losses. Offering a single option contract to the market, with no variance in the choice of term to maturity or strike afforded to the customer is an extreme form of standardization. The standardization of contracts offered to markets is reminiscent of Exchange Traded derivatives rather than those sold Over-the-Counter. There are various

benefits to the dealer in standardizing as described by Stulz (2003). This includes economies of scale as well as a greater degree of liquidity and reduced risk. This model assumes a fully standardized option contract, in the face of a zero-premium condition.

5.2 Analysis

Equilibrium in the model is defined such that for the choices of i and K , there is both profit maximization of the informed trader and there is market efficiency (Kyle, 1985, p. 1318). Market efficiency requires that dealers set prices competitively.¹⁰ These conditions are given in the following statements.

5.2.1 Profit maximization of the Informed

The informed trader chooses i such that no alternative i' results in a higher expected profit, conditional on the knowledge of the final value of the currency. Where π_I is the profit of the informed and Ω_I is the information set of the informed inclusive of S_T :

$$E[\pi_I(i, K) | \Omega_I] \geq E[\pi_I(i', K) | \Omega_I] \quad (1)$$

As is standard for a European call option the profit of the informed trader is equal to the max of zero and the difference between the final value of the currency and the strike price multiplied by the number of contracts taken out by the informed.

$$\pi_I = \text{Max}((S_T - K) i; 0) \quad (2)$$

5.2.2 Market Efficiency

The market maker sets the strike in order to earn zero profits, knowing that there is free entry of competing market makers. Therefore the strike is set equal to the expected value of the exchange rate conditional on d .

¹⁰Kyle (1985) confirms that the condition can be achieved by simulating a Bertrand auction game between at least two risk neutral market makers. This would result in a zero profit condition of the market makers who attempt to compete for their customers and drive prices down to marginal cost.

$$K = E(S_T|d) \quad (3)$$

In the instance of a positive order flow from the informed, if the market maker were to set a strike below the expected future value, the market maker would incur losses. If he was to set it above the expected future value the informed trader would lose and instead choose a competing market maker who offers a lower strike price (one who is willing to take less profits).

5.2.3 Remarks

The interaction between the market maker's problem and the informed trader's problem is made clear in equations 2 and 3. The market maker's pricing rule depends on the contribution of i to order flow d , but the informed trader's choice of i depends on the impact orders have on the market maker's price K (Lyons, 2001). A unique linear equilibrium is achieved in the results of proposition 1 below. Intuitively an informed investor expecting the following pricing rule will maximize profits with the following trading rule. A market maker expecting the following trading rule will set the strike price according to the following pricing rule.

5.3 Results

5.3.1 Proposition 1

There exists a unique equilibrium in which the pricing and trading rules are linear functions given by:

$$K = E(S_T|d) = \omega d \quad (4)$$

$$i = \alpha S_T \quad (5)$$

Where ω and α are:

$$\omega = \frac{1}{2} \left(\frac{\sqrt{\sigma_S^2}}{\sqrt{\sigma_e^2}} \right) \quad (6)$$

$$\alpha = \left(\frac{\sqrt{\sigma_e^2}}{\sqrt{\sigma_S^2}} \right) \quad (7)$$

Equation 4 states that as more customers buy calls on the currency the expected value of the currency rises for the uninformed market maker. The pricing and trading rules depend on the same two parameters, the variance of the uninformed order and the variance of the final value of the currency. This is a consequence of the two being jointly determined (Lyons, 2001).

5.3.2 Proof

The proof relies on assuming behaviour for the informed trader and market maker which can then be shown to satisfy the equilibrium conditions. The informed investor assumes a strike price, set by the market maker, as $K = E(S_T|d) = \omega d$. The variable ω is a coefficient mapping the order flow to the strike price. The important assumption is that the informed trader assumes the market maker utilizes a linear strike price rule. Applying this to the profit function, whilst expanding for d , one gets:

$$\pi_I = (S_T - \omega(i + e))i \quad (8)$$

The informed trader will only participate by going long on a call if he knows S_T to be sufficiently high as to earn profits. He will also participate by shorting calls when S_T is known to be sufficiently low; the model assumes away instances where the informed trader does not exercise the option.

Taking expectations leads to equation 9. This is due to the normal distribution of e , with a mean of zero, the independence of e and i , and the knowledge of S_T by the informed.

$$E(\pi_I|\Omega_I) = (S_T \cdot i - \omega \cdot i^2) \quad (9)$$

The first order maximizing condition of the informed results in the order flow:

$$i = \frac{S_T}{2\omega} \quad (10)$$

The market maker assumes the linear trading rule of the informed is given by $i = \alpha S_T$. The market maker will apply this assumption to the above maximizing condition, which he can determine by working through the optimization problem of the informed trader given his own strike price rule. Thus:

$$\alpha = \frac{1}{2\omega} \quad (11)$$

The market maker uses the observation of order flow as a signal for the final value of the exchange rate. Applying the linear trading rule of the informed to the equation of order flow, $d = e + i$, one gets:

$$d = \alpha S_T + e \quad (12)$$

As a linear combination of jointly normally distributed variables, it too is normal. Therefore:¹¹

$$E(S_T|d) = \frac{\alpha\sigma_S^2}{\sigma_e^2 + \alpha^2\sigma_S^2} \cdot d \quad (13)$$

Coupled with the strike price rule of the market maker $K = E(S_T|d) = \omega d$, one gets the following:

$$\omega = \frac{\alpha\sigma_S^2}{\sigma_e^2 + \alpha^2\sigma_S^2} \quad (14)$$

Solving 14 and 11 simultaneously results in equations 6 and 7 from proposition 1.

5.3.3 Proposition 2

The variance of S_T after observing order flow is lower than the variance of S_T before the order flow signal.

$$\sigma^2(S_T|d) = \sigma_S^2 - \frac{(\alpha\sigma_S^2)^2}{\sigma_e^2 + \alpha^2\sigma_S^2} \quad (15)$$

¹¹Using a general equation for conditional mean (Grossman & Stiglitz, 1980; see the appendix for its application):

$$E(S_T|d) = E(S_T) + \frac{\text{Cov}(S_T, d)}{\text{Var}(d)} \cdot [d - E(d)]$$

5.3.4 Proof

This follows as S_T and d are jointly normally distributed.¹² The second term on the right of 15 is necessarily positive so the variance of S_T is reduced when conditioning on order flow d .

Decreased price volatility due to information-revelation in derivative trades is supported in other models (Detemple & Selden, 1991; Cao, 1999; Grossman, 1988; and Rzepkowski, 2003) In opposition are the feedback models, for instance Frey & Stremme (1997) in which price volatility rises due to derivative trades.

The finding of lowered volatility is consistent with the majority of empirical studies, as discussed in Cao (1999). At times there is ambiguity when there is an overall reduction in volatility in the markets in general, irrespective of derivative trades. When adjusting for this effect there may be no or little change in volatility but in all cases at least a downward movement. In all of the discussed empirical papers there is no finding of an increase in volatility through the inclusion of derivative contracts.

5.4 Remarks

5.4.1 Put Options

Put options are unique in microstructure because they defy a traditional assumption in this field. Buy orders for spots and most derivatives necessarily have a positive effect on the exchange rate. Buy orders for puts necessarily have a negative effect on the exchange rate. They can be termed negative-news trades (Easley, O'Hara & Srinivas, 1998) as they benefit from a decrease in spot price and will be held when there is an expectation of depreciation. The above model can be derived for put options where the purchase of a put lowers the expected future value of the exchange rate. In empirical application negative and positive news trades cannot be aggregated together due to their opposite effect on rates.

¹²Grossman & Stiglitz, 1980

$$\sigma^2(S_T|d) = \sigma_S^2 - \frac{(\text{Cov}(S_T, d))^2}{\sigma_d^2}$$

5.4.2 From Expectations to Price

The transfer mechanism between the dealer's updated expectations of the spot price and the actual spot price is not implicit. This is because the dealer is a derivative trader, not a spot trader as in the original model. They set strike prices, not asset prices in the market. The model achieves a transfer mechanism between the dealer's updated expectations of the spot price and the strike price of options; strike prices rise to meet the expected future value of the exchange rate at the end of the option's life. This is interesting but not central; the important conclusion is that the observation of derivative order flow is the cause of updated expectations of the spot price, amongst derivative dealers.

No assumption has been made about whether derivative dealers deal in spot markets, there is no appearance of spot trades in this framework. In any subsequent period to T , the dealers may enter the spot market taking their updated expectations with them. Market makers who have observed call orders could bring the expected future value of the spot rate with them to the spot market, setting the price of the currency equal to this expectation as in Kyle (1985).¹³

That call market makers deal in spot markets is a realistic assumption considering that derivative market makers often operate in the same institutions that deal in the traditional exchange (DeRosa, 1998). These dealers are often representatives of a large dealer bank and in a position to operate in the spot market. Alternatively if traders remain exclusively in the derivative market they are in a position to inform their counterpart spot traders who operate within the same institution. Derivative traders outright inform their spot traders, allowing them to update their expectations about the spot market leading to a reflection in price. These assumptions could be explored further, yet they are unnecessary when considering only complete markets.

5.4.3 Complete Markets

A complete market is defined in the assumptions surrounding the Black Scholes (1973) model, the standard derivative pricing theorem. What is important to this framework is that the derivative is perfectly replicable or redundant so that the payoffs of the derivative can be replicated perfectly by a portfolio of the

¹³The assumption of free entry of competing market makers holds in Kyle (1985) and the price of the exchange rate is set equal to its expected future value, so as to earn zero profits

underlying asset and the risk free asset. (For the redundancy of derivatives in complete markets see Bjork, 2004 and Deutsche Bundesbank, 2006).

In a complete market, it is not necessary to assume any transfer mechanism between expectations and price at all. One would find no difference between the expected value of the exchange rate determined through order flow in either call or spot markets. A call market maker would learn from this call order flow what a spot market maker would learn in spot order flow; this concept has given rise to the term redundant derivative.

One cannot dismiss the informational flow of derivatives in such instances. For institutions with a freer access to derivative order flow it can be used in the same way as traditional order flow; it is just as informative. This point is important to the thesis that derivative microstructure is justified and valid. The simple model provided above posits that option order flow can be used instead of spot order flow in forecasting exchange rates. In an instance where a financial institution observes a large option order on a currency they could use this information to update expectations and account for its effect on their own exchange rate exposure. The traditional model would have the financial institution ignore the option order on the grounds that it reflects the same information in spot orders, not considering that this spot information may be slower coming to the institution or simply unavailable to it.

Where this simple model fails is in instances where markets are incomplete and derivatives are non-replicable. With no transfer mechanism to spot prices, it is not clear that these expectations will be reflected in the actual exchange rate. If informed trades cluster in option markets rather than spot markets an expected value of the exchange rate will be communicated to option dealers, which differs from that communicated to spot dealers (Easley, O'Hara & Srinivas, 1998).

Back (1993) and Rzepkowski (2003) treat derivative order flow as something which is additive to the information received in spot order flow, as opposed to an equivalent. Only when the information between derivative and spot orders differs, as in an incomplete market, does it have scope to inform. This can be termed the order flow's differential information content (Easley, O'Hara & Srinivas, 1998). The level of differentiation is affected by structural characteristics of the option contract, which can change over time (Rzepkowski 2003). Thus, option order flow has a variable impact on exchange rates. The non-linear relationship between order flow and the exchange rate makes models within in-

complete markets less easily applied empirically as it requires greater data on such structural characteristics for each trade. I assert that the pertinent structural characteristic is delta in both information-revelation and inventory-control models.

Back (1993) shows that an informed trader purchasing a call contract signals to the market the increased probability that the final value of the currency will be greater than the strike price. Orders for calls would do this disproportionately relative to orders for the stock as long as it is not associated with an affine payoff, as long as it has differential information content.¹⁴ The model installs a non-affine structure by calling on an intuitive aspect of option trading. The price pressures of stock and call orders become approximately equal when it becomes likely that the option will finish in the money. The pressure from option orders becomes nearly zero when it becomes likely that the option will finish out of the money (Back, 1993, p. 444). Imagine a scenario where the currency price is far below the strike and the time left in the contracts life is short, not even large bets made on calls on the currency will convince others of a rapid appreciation. One could say the value of information in these orders is low.

Although not defined as such in the paper, this is a delta effect. When an option is deep out of the money it has a near-zero delta and when deep in the money it has a unit delta. Orders for calls which have a large delta carry greater information than those with a small delta. Easley, O'Hara & Srinivas (1998) confirm a delta effect in the information-revelation context. Delta is calculated as a function of the leverage of the option (the number of shares 'controlled' by the option). The higher the leverage, and the delta, the greater is the profit to informed trading. Thus information-based trades will be drawn to options markets with a high delta. When delta is zero, no informed trades cluster in option markets resulting in complete market conditions (the order flow of options and spots do not differ in the information they can provide).

The most recent contribution to derivative microstructure, Rzepkowski (2003), makes this explicit in the inventory-control context, as has been discussed. It builds upon the standard three-stage model by Evans & Lyons (2002a). The model is extended by allowing customers to trade in call options on the currency in addition to the currency itself. In the 'third round' of trading dealers eliminate their foreign exchange exposure to options by taking on a counter-veiling

¹⁴With an affine payoff orders for the derivative convey the same information as orders for the stock.

position in the spot currency. The quantity of the exchange rate that creates a perfect hedge is delta of the options.

Any position in options held by a dealer, which has a high value for delta, regardless of sign, will result in a high quantity of the spot being traded to liquidity traders. A similarly high price response will be necessary to induce the traders to take on these positions.

The empirical application of option order flow on exchange rates thus requires the consideration of delta and those factors which affect delta.

In the Black & Scholes (1973) model of option pricing (Garman & Kohlhagen, 1983, for foreign currency options) delta of a European option is a function of the domestic risk free rate, the foreign risk free rate, the length of the option contract and the variance of the underlying foreign exchange rate. Delta is also a function of the foreign exchange rate at the beginning of the contract and the strike price. In order to hedge option positions in the spot market, as in Rzepkowski (2003), one must hold the delta multiplied by the 'leverage' of the contract; the amount of foreign exchange the option affords the holder the right to buy or sell.

Thus, there are numerous structural characteristics that would find their way into models of this form (they have, as yet, remained untested empirically). Outside of a debate between the validity of assumptions in these models and my own, one will find a stark difference between the complexity of the two types. The simplicity of the above model may better encourage empirical research in option order flow and sets out an idealized setting, as a starting point, where this has been bypassed in the literature.

Worth mentioning, two variables that affect delta are present as variables in typical order flow regressions. The first, spot price, the dependant variable, pushes delta of a long call upwards, increasing the effect of call orders. The second is the foreign risk free rate which is commonly used as an independent variable in hybrid models (Evans and Lyons, 2002b) and this too affects delta. This suggests that endogeneity and multicollinearity would be introduced with the inclusion of delta, although I have not looked deeper than this.

6 Forwards

I now move on to a discussion of forward orders, which make up a little over 10% of world foreign exchange turnover. These contracts allow the writer to purchase a currency at least two days in the future at a rate decided today. In this section I set out the argument that forwards differ from spot orders sufficiently that they must be aggregated separately in constructing order flow. This goes against the trend set in three recent papers.¹⁵

Outside of these three, and with the addition of Gereben, Gyomai and Kiss (2006), it is uncommon to see the use of forward order flow. The inclusion of forwards within models typically dealing with spot orders is done so without consistent method across all four. The papers fail to justify the chosen aggregation method between both types of trade. There appear three methods of incorporation; to discount forward rates to spot rates, to aggregate forwards with spots outright and, lastly, to keep forwards and swaps separate. The last method is the correct one as it avoids grouping liquidity trades with speculative trades that drive prices. The tendency for institutions to utilize forward orders as hedging tools results in them having no effect on exchange rates. Only speculative trades, which create foreign exchange exposure, cause rate changes: an informed trader hoping to profit from an exchange rate transaction must create foreign exchange exposure (Saunders & Cornett, 2005). Easley, O'Hara & Srinivas (1998) confirm that if options are used as hedging vehicles, then their trades are liquidity based and un-informative. They represent third round trades in Evans and Lyons (2002a), having no effect on rates.

There is evidence that strongly supports that firms, especially non-financial firms, use FCDs for hedging purposes and not for speculation (Allayannis & Ofek, 1998). Forwards can be efficiently utilized in hedging operational risk where payments are frequent and indefinite, a characteristic familiar to non-financial firms (Geczy et al, 1997).

Through aggregation one cannot distinguish between a spot or forward purchase of a currency. This is reasonable for speculators who would be indifferent between spot and forward contracts. A 'round trip' has a speculator buy a foreign currency, benefit from its appreciation and then buy the original currency back. This could be done by instead purchasing a forward contract on the foreign

¹⁵Froot & Ramadorai (2002); Bjønnes, Rime & Solheim (2004); Evans & Lyons (2005)

currency and upon its exercise purchasing the original currency back. Hedgers however typically distinguish between spots and forwards. Hedging involves eliminating foreign exchange exposure completely. If a hedger purchased a spot foreign currency, they would undertake to sell that currency in the future for a determined rate through a forward contract. In this instance spots and forwards will be negatively correlated.

In Froot & Ramadorai (2002) the aggregation of forwards and spots requires grouping together contracts of different expiry, which is described as a source of confusion. The forward orders they have are thus discounted to their value at signing using the local-currency interest rate between signing and settling. This method is standard in pricing forward contracts (Hull, 2005).

Complications arise in choosing interest rate data and through its availability. Transactions whose calculated present values are more than \$1000 000 or 30% different to the future value are excluded in case the disparity was created in inaccurate discounting. This may needlessly exclude genuine forward contracts with large deviations between spot and forward rates. In addition, there is little difference to the new data, as nothing fundamental has changed except the readjustment of the purchase/sale price by some factor. This may not warrant the added complications.

The second method, outright aggregation, ignores that spot and forward orders have different dates of expiry. Evans & Lyons' (2005) paper on the forecasting power of micro models does just this, utilizing forward flows in aggregate with spot flows. This is done without discussion. Presumably future and spot contracts are aggregated according to their day of signing. More importantly, this method assumes that the effect on exchange rates of spot and forward orders are alike. Evans & Lyons (2005) is a popular paper and groundbreaking, in that it achieves explanatory power of medium term exchange rates so far unachievable in macro models. It also forecasts the exchange rate more accurately than other papers. On this basis a much more comprehensive discussion of the use of forward orders is warranted.

In a similar light Bjønnes, Rime & Solheim (2004) aggregate spot and future orders, albeit with more discussion; they note that to use spot orders alone would give a distorted picture of the risk participants are willing to take. Nevertheless, their conclusion avoids a discussion on the influence of the forward contracts, which is necessary.

To explain why one must understand the primary finding of Bjønnes, Rime & Solheim (2004): non-financial participants are liquidity providers (hedgers) in the overnight currency market. Financial participants are the aggressors (speculators) and initiate trades and price effects. Drawing an analogy with Evans & Lyons (2002a), financial customers trade in round one and non-financial customers absorb dealer risk by taking on overnight positions in round three. The theory is supported by the findings that a) The order flow of non-financials (financials) is negatively (positively) correlated with changes in the value of the currency, i.e. non-financials purchase during recessions and b) financial orders Granger-cause non-financial orders.

In practical terms, assume financial customers participate more often in foreign investing activities whilst non-financial customers participate in trading activities. If the former demand Krona for investment in attractive Swedish assets the positive order flow will appreciate the Krona. Non-financial traders will be attracted to now relatively cheaper European goods and sell the Swedish Krona for Euros. Their sell orders for the currency come with its appreciation. As a result there is a negative correlation between non-financial order flow and the exchange rate.

Bjønnes et al (2004) also find a significant negative correlation between spot and forward orders for all participants, financial and non-financial. Those who purchase spot orders tend to sell forwards and those who sell forwards tend to purchase spots. This represents hedging behaviour by all participants, although some segments of the market may hedge more than others. The distinction drawn between financial and non-financial customers might instead be a distinction between spot and forward purchasing customers. Spots might be the push orders in the market whilst forwards are the pull orders.

Non-financials may be hedging their positions more often than financials are, by selling forward orders to counteract their holding of foreign assets. As a result, non-financials are liquidity providers because of their liquidity trades in forwards. If forward orders are the true signal of liquidity trading, rather than the proposed financial, non-financial distinction, the results of the paper will be inaccurate:

Through aggregation an element of the financial order flow, that composed of forwards, is liquidity providing although it has been assigned to the push side of the equation. An element of non-financial order flow, composed of spots, is

assigned to the pull side, although it does have an effect on exchange rates.

I suggest there is a push pull differential in the above paper due to the varying information content of spot and forward traders, as forwards are used in non-informative hedging activities. This conclusion cannot be determined conclusively unless forward and spot orders are separated just as non-financial and financial orders are. At the least, my suggestion highlights the point that aggregated forward and spot orders leave uncertainty as to whether this is the case.

Fortunately Gereben, Gyomai & Kiss (2006), the fourth of the above-mentioned papers to utilize forwards, provides a detailed analysis of segregated forward and spot flows making it possible to determine whether these trades have differential effects.

In the paper, there are nine distinct order flow variables; Spots from both domestic and foreign banks and non-banks, forwards from both domestic and foreign banks and non-banks and finally, spot orders of the central bank itself. Correlation analysis shows that, in general, foreign and domestic firms' spot orders are negatively correlated. Overall the paper expects and finds a push pull distinction between foreign and domestic participants. They do not explicitly investigate one between spots and forwards yet strong evidence of this arises and can be extrapolated.

Confirmed in the paper, forward market order flow variables have no push-type impact on the exchange rate. "It seems that the primary channel that aggregates information about the future value of the currency is the spot market," (Gereben, Gyomai & Kiss, 2006). In the liquidity-providing pull customer regression (in which no push trades should be included), forward orders from domestic non-financials are highly significant, resulting in a considerable improvement in R². The coefficient suggests that purchases of forwards are associated with depreciation in the currency, as to be expected on the pull side. This is associated with non-financial institutions. What is occurring is an apparent preference in the market for investors to use the spot market for speculation and the forward market for liquidity trades and hedging, especially amongst non-financials. The precedent set by Gereben et al. (2006) is to ensure spot and forward orders are kept separate as they do indeed have differential information content.

In order to formally define the push and pull equations one must run what can be termed a diagnostic check on the data, in the method of Gereben et

al (2006). The process is unique as the distinction between spot and forward orders is allowed to weigh on which types of order flow constitute the push and pull sides. The method is as follows: a correlation analysis is run between all individual forms of order flow, which are aggregated according to, for instance, foreign/domestic (F/D), financial/non-financial (b/n) and spot/forward (s/f).¹⁶ The paper in discussion includes spot orders of the central bank (Cb), one could include forward orders by the bank. This results in ten sources of order flow, x .

$$x = (Fbs, Fns, Dbs, Dns, Fbf, Fnf, Dbf, Dnf, Cbs, Cbf) \quad (16)$$

A regression is run of order flows on the exchange rate as in 17. From the basis of evidence in the correlation analysis and the regression the push and pull orders are selected. This is done through knowing that push and pull customer orders are negatively correlated and the push (pull) coefficients in the regression will be positive (negative).

$$dS_t = \beta_0 + \sum^i \beta_i x_t^i + e_t \quad (17)$$

One final check would be to summate all push order flow and ensure that it is equal in magnitude but opposite in sign to pull order flow. An equation meant to define the effect of spot and forward orders on the exchange rate must include only those orders which are positively correlated with the rate (the push side) as microstructure provides only a positive effect from buy orders, in both information-revelation and inventory-control specifications. The same holds true for models that forecast, although this was not adhered to in Evans & Lyons (2005) who did not allow for differential information content between spots and forwards.

7 FX Swaps

Institutions regularly use FX swap instruments to attain currencies without exposing themselves to foreign exchange risk. The FX swap has already been described as the most abundant form of foreign exchange trade globally. It is composed of two opposite trades, a spot and a forward, for the same quantity of

¹⁶Think of (b/n) as Bank/Non-Bank

foreign currency. The resultant effect on cumulative order flow is therefore zero. Thus the microstructure approach allows no room for it in theory or in practice. Both spot trades and forwards have been integrated into empirical analysis but when combined into a swap contract they have been excluded.

It is possible, however, for an institution to participate in a swap agreement which contains information about an exchange rate change. For instance a swap order can be made to profit from interest rate spreads between nations, which may not be widely perceived by the market. This provides a causal relationship between order flow for swaps and the exchange rate, which has not been accounted for. An example by Saunders and Cornett (2005) on swap purchases illustrates this clearly.

Take an American bank that can earn more on loans it provides to British citizens, then to citizens of America. If the bank is able to borrow for less than it can earn through loans, it will be able to profit in either market, yet the British one is subject to exchange rate risk. By entering into a swap agreement to purchase pounds today and sell them back at a future date, all exchange rate risk is avoided. The other participant in the deal may request a discount on the spot rate such that in the future, when they are to buy pounds for dollars, they have to pay less than they would today. The American bank on the forward agreement makes a small loss, yet a large gain is made in the interest rate spread between borrowing and lending available in Britain. Thus the financial institution will partake in further loans to the British market. This requires a greater number of swap transactions; a greater number of both spot and forward contracts. Increasing demand for spot orders on pounds means the spot rate for pounds would rise. Increasing forward sales of the pound would lower the forward rate. This widening of the forward-spot exchange rates makes hedging strategies less desirable, until the point where no excess return is received on the foreign strategy above borrowing and lending domestically as dictated by the interest rate parity theorem.¹⁷ It is important to note that in this model it is only the spot transaction that affects the spot exchange rate, not the forward transaction.¹⁸

Bjønnes et al (2004) say, “A swap is by definition a position that nets itself out.

¹⁷Interest Rate Parity Theorem (B - borrowing L - lending) (Frenkel, 1976)

$$1 + r_d^B = \frac{1}{S_T} [1 + r_f^L] . F$$

¹⁸A swap can be either a combined spot/forward or a forward/forward, they are considered the same by the BIS. It is only the former definition of a swap that is considered.

In other words, we can ignore trading in swaps.” In light of the above example one should not ignore swaps. The example shows a macroeconomic variable, foreign interest rates, create a desire for a swap transaction with a resultant effect on spot price. This has not been allowed in standard order flow as it is assumed that spot and forward orders, the two legs of the swap transaction, have the same effect on spot rates and cancel each other out. As argued in the previous section, this need not be true. To incorporate their effects the matter of their zero net order flow must be addressed.

Microstructure signs trade from the perspective of the initiator to the deal. When entering into a swap, this is likely the same person for both legs of the transaction. In a special example, the participant may approach the market maker for a spot transaction and the market maker, unwilling to carry exposure, insists on an equally sized forward contract. Both the customer and the dealer initiate separate legs of the transaction. This would generate a non-zero order flow equal to twice the value of the spot transaction (much like turnover figures), signed positively in favour of the customer. One could assume this scenario holds, yet there is no reason for it to be typical of all swap transactions.

An alternative is to utilize the spot component of the swap alone as it may be only this component that affects price. The example of Saunders and Cornett (2005) supports this approach; in returning to the equilibrium of IRPT, increasing demand for forwards does not affect the spot rate, it only changes the forward rate. As discussed, evidence from Gereben et al. (2006) supports this; they find forward order flow has no significant push side effect and no effect on the spot rate. This need not be true in all cases of forward orders, although it is true when the forward is used as a hedging tool on the pull side. In this instance, I propose, one can extract the spot order from the swap transaction.

There is a justification for both spots and forwards to be positively correlated with exchange rates; speculators in the market could reasonably purchase a spot or forward contract in expectation of an appreciation. In the discussion on forwards this required defining the nature of the forward, as a speculative tool or one for hedging, before considering its inclusion. An FX swap is necessarily entered into as a foreign exchange hedging tool. Extracting spot trades from swaps is thus justified along these terms.

A more certain approach would be to run an extended diagnostic check on the data. The method is similar to that described in the section on forwards. If spot

orders are discovered to be aggressive and price setting, whilst forward orders are primarily liquidity trades, one has evidence that the same holds true in swap contracts. To further this, if financial institutions compose a large degree of the swap market, this alludes to hedging behaviour. Financial firms utilize swaps as a hedging tool often and more so than non-financial firms (Geczy et al, 1997). Swaps can be customized to eliminate basis risk to a greater degree than forwards, and due to the fixed costs associated with this, it is cheaper within a single swap than a series of forwards.¹⁹ This suits financial institutions with predetermined foreign exchange debts.

8 Conclusion

The focus of this analysis has been on customer order flow models in foreign exchange microstructure and the inclusion of derivative orders within this framework. Three derivatives compose the majority of derivative trades on foreign exchange and represent two-thirds of total turnover in FX markets (Bank of International Settlements, 2007). These are FX swaps, forwards and options and they are addressed by this paper.

The evolution of the field of microstructure is bound to continue in the manner in which it began. The field attempts to model as realistically as it may, the manner in which real market makers receive market information and adjust prices accordingly. The modeling of derivative order flow is the next step, as evidenced by the prevalence and continuing rise of derivative products in the market for foreign exchange. The approach I have taken in this paper, in the case of options, is to take an existing traditional model of Kyle (1985) and include in it orders for European call options. A process of information-revelation occurs through the observation of option order flow, which updates the expected future value of the exchange rate. The strengths and weaknesses of the model rest on its simplicity. It indicates that option orders are as informative as spot orders when in a complete market, providing a justification for this form of derivative order flow. This is relevant to those institutions with greater access to option data or those that observe large option orders before they do spot orders. A weakness is that it fails to address the variable impact of option orders in incomplete markets

¹⁹Basis risk is generated when there are differences between the asset that needs hedging and the derivative contract that is used to hedge it. The risk arises in that the final value of these two concerns may differ at the end of the derivative contract.

through the value of delta. Rzepkowski (2003) demonstrates this effect. What is left is for this to be tested empirically for the first time.

In the case of forwards I have discussed the rationale and method used by recent empirical papers that incorporate forwards in traditional models. The theoretical foundation of forward order flow is not treated differently to that of spot order flow. As such the above-mentioned papers perpetuate a trend of assuming the two can be aggregated together. Gereben Gyomai and Kiss (2006), the most recent, separates the two. This is necessary in that any difference in the choice amongst investors to use forwards or swaps in either speculative or hedging behaviour will cause the two instruments to lie on different sides of the push/pull divide defined by Bjønnes, Rime & Solheim (2004) (price-driving/liquidity-providing orders). In this paper, I propose that forwards are commonly used in hedging activities and likely to have a reduced effect on exchange rates. In other words they are liquidity providing. Though this may not necessarily be true for all markets and currencies, it must be allowed for by keeping spot and forward orders separate.

This complication has positive implications for the utilization of FX swaps in order flow analysis. As a contract of two equal and opposite trades, its order flow is necessarily zero and under current theory it will have no effect on rates. Yet the principles of the Interest Rate Parity Theorem indicate that swaps do induce changes on spot rates (Saunders & Cornett, 2005). It is the spot leg of the transaction that impinges on spot rates, not the forward leg. In considering that forwards have no effect on rates when used in hedging activities, as is necessarily true for an FX swap, one can justify the use of FX swap order flow constructed from the spot leg.

A drawback of the rarity of order flow data, as well as that of derivative orders, is that the various hypotheses made have not been tested empirically in this paper. Given the opportunity to do so, the following questions would test the primary findings:

Does call order flow explain exchange rate changes and what is the effect of delta on this relationship? Are forward orders negatively correlated with exchange rates such that they represent liquidity trades in the market? Can the spot leg of FX swap transactions explain movements in the exchange rate?

In calculating daily turnover statistics, central banks receive daily orders for spot, forward and FX swap transactions from dealer banks. They have the

ability to construct spot and derivative order flow variables.²⁰ This offers the ability to forecast exchange rates (Evans & Lyons 2005), determine the segment of the market that drives rates and determine which segments respond to such price changes (Gereben Gyomai & Kiss, 2006). Incorporating derivatives in order flow analyses would allow researchers to determine which instruments are the first to carry private information and which are the most pertinent to rates. It would also greatly expand the proportion of foreign exchange transactions enacted each day that can be incorporated in microstructure models.

²⁰The South African Reserve Bank collects daily data from banks on spot, forward and swap transactions for the Rand in order to compute net average daily turnover in South African foreign Exchange. This is published in the Quarterly Bulletin of the SARB (datasets 5450M to 5461M). The (private) raw data could be used to construct spot and derivative order flow, although this has not been done. Nevertheless, options are not similarly reported.

9 Appendix

With respect to Proposition 1 and 2

To Show:

$$E(S_T|d) = \frac{\alpha\sigma_S^2}{\sigma_e^2 + \alpha^2\sigma_S^2} \cdot d$$

Given:

$$d = \alpha S_T + e$$

$$E(S_T|d) = E(S_T) + \frac{\text{Cov}(S_T, d)}{\text{Var}(d)} \cdot [d - E(d)] \text{ (Grossman \& Stiglitz, 1980)}$$

$$E(S_T) = 0, E(d) = 0$$

Proof:

$$\text{Cov}(S_T, d) = E[S_T - E(S_T)] \cdot [d - E(d)]$$

$$= E[S_T \cdot d]$$

$$= E[S_T \cdot (\alpha S_T + e)]$$

$$= \alpha E[S_T^2]$$

$$= \alpha \cdot \sigma_T^2$$

$$\text{Var}(d) = E[d - E(d)]^2$$

$$= E[\alpha S_T + e]^2$$

$$= E[e^2 + \alpha^2 S_T^2 + 2\alpha S_T e]$$

$$\sigma_e^2 + \alpha^2 \sigma_S^2$$

Therefore:

$$E(S_T|d) = \frac{\alpha\sigma_S^2}{\sigma_e^2 + \alpha^2\sigma_S^2} \cdot d$$

10 References

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