

PRICE DISCOVERY IN FX MARKETS:
A COMPREHENSIVE COMPARISON OF INDICATIVE AND FIRM QUOTES

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ABSTRACT

PRICE DISCOVERY IN FX MARKETS: A COMPREHENSIVE COMPARISON OF INDICATIVE AND FIRM QUOTES

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This dissertation provides a comprehensive analysis of the price discovery process in the foreign exchange market by comparing the indicative quotes from the Reuters Platform and tradeable/firm quotes from the Reuters Matching System. Comparing tradeable quotes with indicative quotes enhances the understanding of the price discovery process in foreign exchange markets, as these two types of quotes have important structural differences due to their trading environment. Several studies have been conducted on price discovery in the stock market based on cross-listed stocks; however, this issue is under-investigated for the foreign exchange market since the market is highly fragmented and price and trade data for several platforms are not easily accessible. Moreover, the few studies conducted on the subject find contradicting results. In this dissertation, first, by utilizing updated data, the prevailing uncertainty regarding which quotation type leads in price discovery is clarified. The findings indicate that the Reuters Matching System generally dominates price discovery. This dominance is evidenced by the substantial variation in currency pairs, particularly when considering the information and component share measures. However, it is shown that indicative quotes also play a significant role, with their

information leadership shares reaching at least 40% in most exchange rates. The significant differences observed between the estimated price discovery measures underscore the importance of selecting appropriate price discovery metrics. The study also identifies the determinants of price discovery, revealing that the bid-ask spread, number of quotations, and volatility are significant market variables influencing price discovery between indicative and tradeable quotations.

Keywords: FX Market, Price Discovery, Price Discovery Measures.



ÖZ

DÖVİZ PİYASALARINDA FİYAT KEŞFİ: GÖSTERGE KOTASYONLAR İLE KESİN KOTASYONLARIN KAPSAMLI BİR KARŞILAŞTIRMASI

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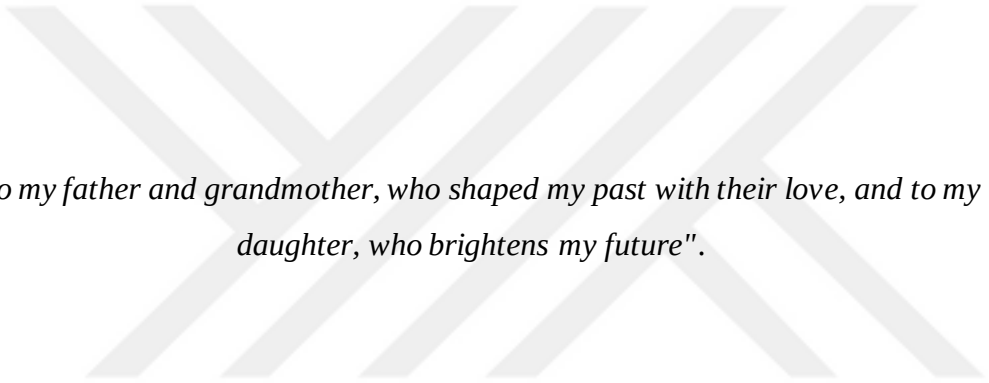
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Bu tez, Reuters Platformu'ndan alınan gösterge niteliğindeki kotasyonlar ile Reuters Eşleştirme Sistemi'nden alınan alım satılabilir/kesin kotasyonları karşılaştırarak döviz piyasasındaki fiyat keşif sürecinin kapsamlı bir analizini sunmaktadır. Alım satım konu olan kotasyonların gösterge niteliğindeki kotasyonlarla karşılaştırılması, bu iki kotasyon türünün işlem ortamları nedeniyle önemli yapısal farklılıklara sahip olması sebebiyle, döviz piyasalarındaki fiyat keşfi sürecinin anlaşılmasına katkı sağlamaktadır. Hisse senedi piyasasında fiyat keşfi üzerine çapraz kote hisse senetlerine dayalı çeşitli çalışmalar yapılmış olmasına rağmen, piyasanın oldukça parçalı olması ve çeşitli platformlar için fiyat ve işlem verilerine kolayca erişilememesi nedeniyle bu konu döviz piyasası için yeterince araştırılmamıştır. Dahası, bu konuda yapılan az sayıdaki çalışma çelişkili sonuçlar bulmaktadır. Bu tezde, ilk olarak, güncellenmiş veriler kullanılarak, fiyat keşfinde hangi kotasyon tipinin lider olduğuna ilişkin mevcut belirsizlik açıklığa kavuşturulmuştur. Bulgular, Reuters Eşleştirme Sistemi'nin genel olarak fiyat keşfinde lider olduğunu göstermektedir. Bu durum,

özellikle bilgi ve bileşen payı ölçümleri dikkate alındığında, farklı döviz kurlarında önemli değişkenlikle kanıtlanmaktadır. Bununla birlikte, bilgi liderliği payı ölçüsünün çoğu döviz kurunda en az %40'a ulaştığı ve gösterge niteliğindeki kotasyonların da fiyat keşfinde önemli bir rol oynadığı gösterilmiştir. Tahmin edilen fiyat keşfi ölçütleri arasında gözlemlenen önemli farklılıklar, uygun ölçütlerinin seçilmesinin önemini vurgulamaktadır. Bu çalışma aynı zamanda fiyat keşfinin belirleyicilerini de ortaya çıkarmakta ve alış satış farkı, kotasyon sayısı ve oynaklığın gösterge ve kesin kotasyonlar arasındaki fiyat keşfini etkileyen önemli piyasa değişkenleri olduğunu ortaya koymaktadır.

Anahtar Kelimeler: Döviz Piyasası, Fiyat Keşfi, Fiyat Keşfi Ölçüleri



"To my father and grandmother, who shaped my past with their love, and to my daughter, who brightens my future".

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TABLE OF CONTENTS

PLAGIARISM.....	iii
ABSTRACT	iv
ÖZ.....	vi
DEDICATION	viii
ACKNOWLEDGMENTS	ix
TABLE OF CONTENTS	x
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF ABBREVIATIONS	xiv
CHAPTERS	
1. INTRODUCTION.....	1
2. STRUCTURE OF FOREIGN EXCHANGE MARKETS	6
2.1. Traditional Structure of FX Markets	6
2.2. Electronic Broking Systems	8
2.3. Structural Changes in FX Markets	10
3. PRICE DISCOVERY IN FOREIGN EXCHANGE MARKETS	19
3.1 Theoretical Microstructure Models of FX Market	21
3.2 Empirical Findings on Price Discovery	26
3.2.1 Private Information in the FX Market	27
3.2.2 Liquidity and Price Discovery in the FX Markets	28
3.2.3 Heterogeneity of Market Participants in the FX Markets.....	29
3.2.4 Market Microstructure and Price Discovery in the FX Markets	31
3.3 Data in the FX Market	33
3.4 Market Fragmentation and Price Discovery	35
4. DATA AND METHODOLOGY	38
4.1 Data	38
4.2 Methodology	41
4.2.1 Information Share Measure	42
4.2.2 Component Share Measure	43

4.2.3	Information Leadership Share Measure	44
4.2.4	Comparison of the Price Discovery Measures	45
4.2.5	Estimation of the Price Discovery Measures	46
5.	RESULTS AND ANALYSIS	48
5.1	Preliminary Data Analysis.....	48
5.2	Results on Price Discovery Measures	53
5.3	Determinants of Price Discovery.....	65
5.4	Robustness Checks	85
6.	CONCLUSION	87
	REFERENCES.....	90
	A. DISCUSSION OF INDIVIDUAL CURRENCY PAIR REGRESSION	
	ESTIMATIONS	100
	B. CURRICULUM VITAE.....	170
	C. TURKISH SUMMARY / TÜRKÇE ÖZET.....	171
	D. THESIS PERMISSION FORM / TEZ İZİN FORMU.....	189

LIST OF TABLES

Table 2.1 Share of Major Electronic Computer Networks in FX Trading.....	13
Table 4.1 Tradeable Data Counts	39
Table 4.2 Indicative and Tradeable Quote Counts	40
Table 4.3 Time Slices	40
Table 5.1 Variance Levels and Tests of Equality of Variance	54
Table 5.2 Price Discovery Shares of Indicative Quotations	63
Table 5.3 Definitions of Explanatory Variables	67
Table 5.4 Descriptive Statistics of Explanatory Variables	68
Table 5.5 Correlation Matrix of Explanatory Variables	71
Table 5.6 Summary of Model 1 Results – Full Sample	75
Table 5.7 Summary of Model 1 Results – London Market HoursTable	76
Table 5.8 Summary of Model 1 Results – Local Market Hours	77
Table 5.9 Summary of Model 2 Results – Full Sample	78
Table 5.10 Summary of Model 2 Results – London Market Hours	79
Table 5.11 Summary of Model 2 Results – Local Market Hours	80
Table 5.12 Summary of Model 3 Results – Full Sample	81
Table 5.13 Summary of Model 3 Results – London Market Hours	82
Table 5.14 Summary of Model 3 Results – Local Market Hours	83
Table 5.15 Price Discovery Measure Estimations for Longer Time Period.....	86

LIST OF FIGURES

Figure 2.1 Trading Volume of Spot FX Market.....	11
Figure 2.2 Share of Market Players in the FX Market	14
Figure 5.1 Intraday Seasonality.....	53
Figure 5.2 Cross-Correlations	62
Figure 5.3 Price Discovery Shares of Indicative Quotations	64



LIST OF ABBREVIATIONS

AUD	Australian Dollar
BIS	Bank for International Settlements
CAD	Canadian Dollar
CHF	Swiss Franc
CIP	Covered Interest Parity
CS	Component Share
CNY	Chinese Yuan
DEM	Deutschemark
ECN	Electronic Communication Network
ECNs	Electronic Communication Networks
EBS	Electronic Broking Service
EME	Emerging Market Economies
EUR	Euro
FX	Foreign Exchange
GMT	Greenwich Mean Time
GBP	British Pound
HFT	High-Frequency Trading
HUF	Hungarian Forint
ILS	Information Leadership Share
IND	Indicative
IS	Information Share
JPY	Japanese Yen
KRW	South Korean Won
MXN	Mexican Peso
NDF	Non-Deliverable Forward
NQR	Number of Quotations Ratio
NZD	New Zealand Dollar

OTC	Over-The-Counter
PDM	Price Discovery Measure
PLN	Polish Zloty
PPP	Purchasing Power Parity
SGD	Singapore Dollar
THB	Thai Baht
TRY	Turkish Lira
TRD	Tradeable
TS	Trading Session
UIP	Uncovered Interest Parity
USD	United States Dollar
VECM	Vector Error Correction Model
VIX	Volatility Index
ZAR	South African Rand

CHAPTER 1

INTRODUCTION

The literature on market microstructure analyzes the behavior and formation of prices in asset markets. Fundamental to this line of research is the belief that characteristics of the particular trading mechanisms used in markets are important in influencing the behavior of asset prices (Easley and O'hara 2003). A critical area of the microstructure research is price formation and discovery which examines how new information is incorporated into asset prices. In the foreign exchange (FX) market, information can be incorporated into prices across different trading platforms and price discovery reflects relative informational superiority and identifies the market structure that leads the price discovery process.

FX market is decentralized with transactions executed in various trading environments. Unlike centralized markets, such as securities markets where trades occur at publicly announced prices and all traders face the same opportunities, in a decentralized system prices are quoted and transactions are made in private meetings. An important consequence of decentralization is fragmentation, meaning that since not all dealer quotes are observable, transactions may occur at the same time at different prices (Sarno and Taylor, 2001). Consequently, unlike the securities markets, the FX market experiences varying prices and trading opportunities across multiple platforms.

As market fragmentation intensifies, examining the extent and direction of price discovery becomes crucial. Understanding which market first incorporates new information about an asset, and how trading mechanisms, trading activity, and the prevalence of private information affect the efficacy of price discovery, is essential in order to grasp the overall price discovery process in a market.

In this dissertation, the price discovery in the FX market is analyzed by comparing the most followed types of quotations: indicative quotes from the Reuters EFX page and tradeable/firm quotes from the Reuters Matching System. Indicative quotes are the traditional information source available to all market players globally while firm quotes are from the Reuters Matching System which has a standard closed-order book which means that the deals are completed with deal-matching within the system and information on these deals is not publicly available.

Comparing tradeable quotes with indicative quotes enhances the understanding of the price discovery process in FX markets because these two types of quotes have important structural differences due to their trading environment; so, they are expected to have different features considering their information content. First of all, the participants of the platforms or the end-users of the quotes are different. The users of the Reuters Matching System are banks, financial institutions, and, hedge funds which are accepted as the well-informed investors in the literature. Second, a wide range of market makers contribute to the EFX indicative quotes compared to the very selective nature of the Reuters Matching System. Third, while tradeable quotes are subject to trade obligations, indicative quotes are mostly for advertising but the studies using these quotes claim that banks are likely to trade against their quotes if called within a short time after appearance due to reputation considerations (Martens and Kofman, 1998). Lastly, there is asymmetry in terms of anonymity between indicative and tradeable quotes since indicative quotes are published showing the name of the financial institution while the Reuters Matching System does not show the identity of the quoter before the trade, meaning there is pre-trade anonymity.

Several studies have been conducted on price discovery in the stock market based on cross-listed stocks; however, this issue is under-investigated for the FX market since the market is highly fragmented and price and trade data for several platforms is not easily accessible. Comparing indicative and tradeable quotes, Goodhart et al. (1996) find that the time series characteristic of prices is similar whereas the distribution of bid-ask spreads is significantly different. Danielsson and Payne (2002) show that price discovery takes place dominantly in tradeable quotes, where over 90% of the relevant

information enters into the tradeable quotes first and then gets impounded in the indicative quotes. Conversely, Phylaktis and Chen (2009) find that the information share of indicative quotes is about 80% and indicative price data possess higher information when there is substantial increase in the transaction frequency in trades in the matching system. Thus, the few studies conducted on the subject find contradicting results.

There are several contributions of this dissertation to the literature: First, this research solves an issue that have contradicting results in the literature with an analysis based on updated data. Second, the FX market has changed significantly from the traditional setting in the 1990s. On the one hand, today's FX market is fragmented in the sense that there are several trading platforms, most of the participants are connected in more than one way, and liquidity providers are not only dealers but also non-dealer institutions, which is a very diverse group with different trading motivations and techniques. On the other hand, the FX market is concentrated in terms of major dealers and institutions providing liquidity and trading is more concentrated in terms of geography. Therefore, revisiting this issue is important to enhance our understanding of the price discovery process since these structural changes from the traditional setting have several important implications for the price discovery process. Third, existing literature suggests that it is critical to consider the focus of the price discovery measures on the speed and the noise of the series when examining the price discovery shares of different market platforms especially when the price series are different in terms of noisiness due to differences in market frictions. In order to address this issue, this dissertation compares the price discovery process between indicative and tradeable quotations by calculating three price discovery measures; namely, the component share, information share and information leadership share whose focus are different on the speed and the noise of the series. Last but not the least, the literature and anecdotal evidence suggests that the price discovery process may differ for currency pairs based on overall market liquidity and depth as well as institutional factors that may affect the information environment. Thus, several currency pairs with different levels of market liquidity are included in the sample in order to see whether there are differences in the price discovery process among these currency pairs.

In the first part of the analyses, findings show that the dominant location for price discovery is the Reuters Matching System in general with significant variation in the currency pairs, especially when the information and component share measures are considered. It is also observed that the information leadership shares of indicative quotes reach at least 40% in most of the exchange rates, suggesting that almost 40% of the new information is first impounded into indicative quotations. The significant differences between the estimated price discovery measures support the argument of Putnins (2013) arguing that if the noise in the price series differs, the information and component share metrics measure a combination of leadership in impounding new information and relative avoidance of noise, to varying degrees. These findings highlight the importance of the choice of the price discovery measure when there are varying degrees of noise between the series that are being compared.

In the second part of the analyses, the determinants of price discovery are examined. Findings show that the bid-ask spread ratio, the ratio of the number of quotations and the volatility ratio between the indicative and tradeable prices are the significant market variables in explaining the variation in the price discovery measures. The volatility ratio is mostly significant for the component and information share measures and negatively related with the price discovery share of the indicative quotes. It is possible to argue that this is due to the focus of these metrics on the noisiness of a series. The ratio of the number of quotations is mostly significant and positively related to the information leadership share since it represents trading activity and convey new information about the level of the exchange rate.

The results also show that the bid-ask spread ratio is inversely related with the component and information share measures and positively related with the information leadership measure of the indicative series. This difference also seems to be a result of the focus of the price discovery measures. The information leadership measure, by only focusing on the speed of information, actually identifies the effect of the tradeable spread on the price discovery of the indicative/tradeable quotes. Furthermore, the results of the information leadership measure suggest that the Reuters Matching Platform acts as an interdealer platform and spreads follow the predictions of Osler et

al's (2011) model where market makers widen their bid-ask spreads when they can identify better informed customers. Finally, variables describing the time of the day also have significant effect on the price discovery shares of both indicative and tradeable quotations, highlighting the importance of taking into account whether different markets are in session (such as London, US or the local market) while evaluating the price discovery process.

In summary, this dissertation provides a deeper understanding of price discovery in the FX market by providing a detailed comparison of tradeable/firm quotes with indicative quotes. The findings emphasize the importance of volatility, trading activity and bid-ask spreads in terms of price discovery in this market. Moreover, the findings of the study underline the importance of selecting the appropriate price discovery measure in different market environments. The research also resolves the previous contradictions in the literature and sets the stage for future studies to explore the evolving dynamics of price discovery in decentralized markets.

CHAPTER 2

STRUCTURE OF FOREIGN EXCHANGE MARKETS

Foreign exchange rates are of enormous importance to the global economy. FX rates affect commodity prices and import costs, they affect employment and output through real exchange rates, and they affect international capital flows through the risks and returns of various assets (King et. al, 2012). In parallel with this importance, the FX market is the largest in the world financial markets with an average daily spot trading volume of about \$2.1 trillion per day in April 2022. There are several differences in the functioning of FX markets compared to stock and bond markets, which make FX markets very special in terms of the price discovery process. To understand how information is incorporated into prices, this chapter aims to provide information on the structure of the FX market and how the market structure has evolved over time.

In this chapter, we first explain the traditional institutional features of FX markets, then provide information on electronic trading platforms and discuss structural changes in the functioning of FX markets and the current structure of the market. Finally, we provide information on the price data available in the FX markets.

2.1. Traditional Structure of FX Markets

Originally, FX trading was among the traders of goods and services. Over the centuries, however, FX trading has expanded to include various agents with different motives, such as speculation, hedging and arbitrage. As a result, the main market participants today are dealers, asset managers, central banks, retail traders and, more recently, high-frequency traders. Among this wide range of market participants, dealers fulfil the function of providing liquidity by standing ready to trade with anyone

who needs foreign exchange at a moment's notice. In practice, an agent wishing to initiate a trade calls a dealer and asks for the price of the currency for a specific quantity, and the dealer quotes a selling price and a buying price. The agent then decides whether to buy, sell or pass. Markets of this type, where trading takes place directly between two parties without a central exchange or broker, are called over-the-counter (OTC) markets (King et al., 2012). In FX markets, there is no exchange or physical location or screen where all tradable dealer quotes are consolidated or where dealers meet clients. There are several trading platforms that provide exchange-like services, which will be mentioned in the following section; however, it is important to emphasise that there is no platform that is able to capture the entire market. The FX market is therefore described as a decentralised multi-dealer market (Lyons, 2001). In contrast to centralised markets, such as the securities market, where trading takes place at a publicly quoted price and all traders in the market have the same trading opportunities, in a decentralised system prices are quoted and transactions take place in private meetings. An important consequence of decentralisation is fragmentation, i.e. because not all trader quotes are observable, transactions can occur simultaneously at different prices (Sarno and Taylor, 2001). Therefore, unlike the securities market, there may be different prices and trading opportunities on different platforms. Another consequence of decentralisation is low transparency. Compared to other highly transparent markets where trades are made public within minutes by law, trades in FX markets are not observable (Sarno and Taylor, 2001). The decentralisation of the FX market is also evident when considering the interbank and retail markets, which means that the FX market is a two-tier market where trading takes place between dealers in the interbank market and between banks and their non-bank customers in the retail market (Evans, 2010). Before the mid-1990s, the most dominant form of FX trading was direct trading (usually by telephone) in the interbank market, but since then interbank trading has taken the indirect form of dealers trading through electronic trading platforms. More information on electronic trading platforms and a discussion of the changes in this two-tier market structure is provided in the next section.

Another result of the decentralisation of the FX market is the unregulated nature of the market. Since the FX market does not have a trading floor and is spread across several

financial centers in different countries, it is not possible to impose rules and regulations on its operations and participants. Thus, the rules of trading in FX markets are not regulated or administered by an external supervisory authority, but are the result of the natural evolution of the market itself (Gereben, 2005). Lyons (2001) highlights three characteristics of the FX market that distinguish it from other markets: high trading volume, high interdealer trading volume and low transparency. Another point to be added to this list is the unregulated nature of the FX market. With the exception of the dominance of interdealer trading, these characteristics are still valid today.

2.2. Electronic Broking Systems

Until the late 1980s, FX transactions relied primarily on telephone-based technologies. In 1992, Reuters began offering the first electronic broking service, known as Thomson Reuters Matching, to participants in the interbank market. In the early 1990s, a consortium of banks launched the Electronic Broking Service (EBS) to provide a similar service (Gallardo and Heath, 2009). Electronic broking platforms dominated interdealer trading in the liquid pairs by the end of the 1990s. The rapid migration of interdealer trading to electronic broking platforms was the result of the anonymity and electronic nature of the platforms. Dealers preferred these platforms to direct trading because they could hide their positions while trading, and these platforms were also faster and more operationally efficient (King et al, 2012). Between these two platforms, liquidity was concentrated on one platform for each currency due to network externalities. Interbank trading in EUR, JPY and CHF is mainly located on EBS, while Reuters dominates trading in GBP, AUD, CAD and the other currencies (King, 2012).

These trading platforms offer some of the services of global exchanges and clearing houses. They have a standard closed order book, meaning that trades are completed with deal matching within the system. In these trading platforms, no agent is specifically tasked with providing liquidity. Any agent can either supply liquidity ('make') by placing a limit order or demand liquidity ('take') by entering a market order (King et al, 2013). The quotes provided are firm quotes and are subject to transaction obligations. Unlike direct trading, the dealer decides when to place a limit order and

the maximum amount to trade if the limit order is filled. In addition, the dealer can place a limit order to buy or sell. This is fundamentally different from direct trading, where dealers provide two-way quotes (Bjornes and Rime, 2005).

The quotes on the trader's screen are anonymous, but the identity of the counterparty is revealed after the trade. The system automatically checks whether the dealer screening the quotes has sufficient open credit limits with the originator of the quote. This system eliminates trade failures due to insufficient credit limits and reduces counterparty risk within the system. The system also allows for net rather than gross settlement of trades between counterparties, which significantly reduces transaction costs (Sarno and Taylor, 2001).

Trading through electronic brokerage systems has brought some benefits not only to dealers, but also to other participants in the FX trading system. First, fewer trades were sufficient to efficiently allocate a given volume, so that risk sharing among dealers became more efficient and managing the risks associated with executing large client orders became easier (Evans and Rime, 2019). This also means that dealers can execute transactions more quickly, reducing the cost of holding inventory. Second, the anonymous trading environment, which did not allow price discrimination, significantly reduced trading costs for small banks. Third, because trades were reported more efficiently by electronic brokers than by voice brokers, post-trade transparency increased (King, 2012). Fourth, because the electronic broking systems provide a live price stream showing the best bid and ask prices for all participating trades, they improve pre-trade transparency. In addition, these systems reduce information acquisition costs by providing real-time, tradable quotes not only to system participants but also to the market at large. Fifth, these systems significantly reduce operating costs because they are highly automated (Ding, 2010).

On the other hand, some disadvantages of these systems are also discussed in the literature. Lyons (1997) argues that before the introduction of electronic broking systems, small dealers gathered information about the market through their transactions with large dealers. Bloomfield and O'Hara (1999, 2000) suggest that

electronic trading may reduce the active participation of both large and small dealers in the market, as small banks now obtain similar information without real transactions, as they could observe tradeable prices. Furthermore, Ding and Hiltrop (2010) argues that electronic trading may reduce the transaction volume and profit of large dealers, as dealers without information advantages can quote competitive spreads, as the systems share information among dealers without significant costs. As a result, large dealers may widen their spreads in response to the reduction in their profits.

2.3. Structural Changes in FX Markets

The fragmented and unregulated OTC structure of FX markets makes it almost impossible to obtain data covering the entire market. The only comprehensive source of information that provides a snapshot of the FX market is the BIS Triennial Surveys. Therefore, this section is based on the data provided by the BIS Triennial Surveys between 1998 and 2022, as well as the articles written by BIS researchers to accompany the surveys.

First, it is important to note that the volume of the (spot) FX market shows a tremendous increase between 1989 and 2022; the average daily spot trading volume was \$317 billion per day in 1989 and reached about \$2.1 trillion per day in 2022. Except between 1998 and 2001 and 2013 and 2016, the volume of the FX markets has shown a continuous increase for three consecutive years.

This increase in volume was the result of several long-term structural and short-term market factors. While the introduction of the euro, the consolidation of the banking industry and the growth of electronic broking had contributed to a decline in market activity between 1998 and 2001 (Galati, 2001), these forces were more muted in the following years or overwhelmed by short-term incentives for currency trading in the period that followed, which was characterised by interest rate differentials and exchange rate movements that encouraged speculative strategies and hedging activity (Galati and Melvin, 2004). The 2007 survey found that the increase in trading activity between 2004 and 2007 was the result of several main factors. The first is the rapid

growth in turnover of financial clients such as investment funds, hedge funds and currency funds. Interest rate differentials and long-term trends were also valid during this three-year period, so carry trades and leveraged investments were actively used.

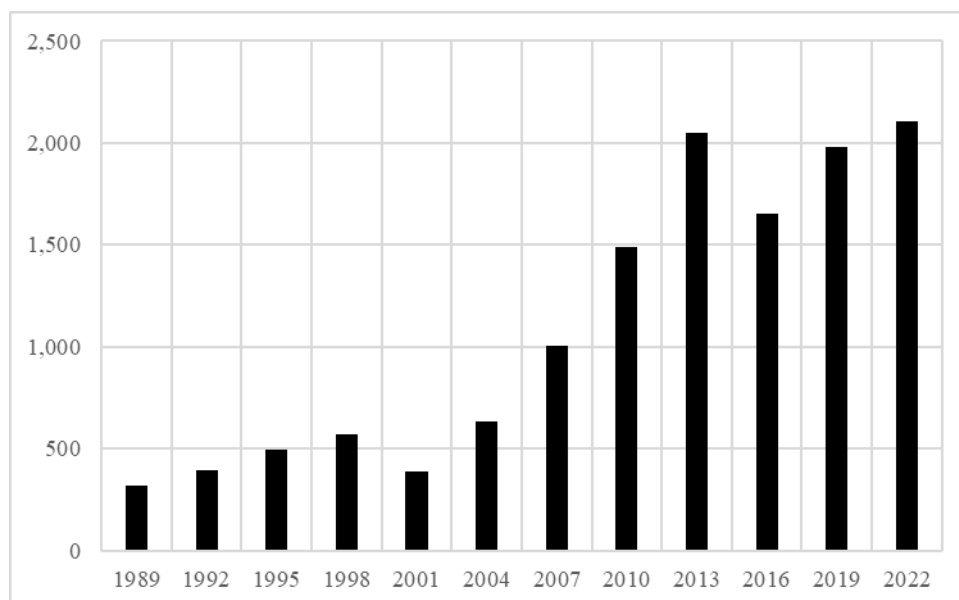


Figure 2.1 Trading Volume of Spot FX Market This figure shows the daily average spot trading volume in the FX market in billions of US dollars between 1998 and 2022 based on BIS Triennial Surveys.

In addition, the international diversification of portfolios, motivated by the high returns of emerging market instruments, created direct and indirect demand for emerging market currencies. The growing role of algorithmic trading, thanks to technological advances in electronic trading systems, should also be mentioned in this context. The second factor is related to the growing importance of emerging market currencies. As noted above, emerging market financial instruments offered high attractive risk-adjusted returns, which directly and indirectly increased the demand for their currencies. The increased demand for emerging market currencies by non-residents of these countries was reflected in a sharp increase in market activity in offshore markets (Galati and Heath, 2007). The 2010 survey showed a surge in market turnover to around \$1.5 trillion, an increase of 48% on 2007 figures. King and Rime (2010) discuss that there are three main developments behind this sharp increase: (i) increased turnover by high-frequency traders; (ii) greater activity by smaller banks as clients of top dealers in major currencies; and (iii) the emergence of retail investors. King and

Rime (2010) argue that all these factors are related to the increasing role of electronic execution. The proliferation of electronic execution methods has reduced transaction costs and increased market liquidity, encouraging greater participation by a wide range of client types. Large dealers have invested in single-bank proprietary systems, providing tight bid-ask spreads; smaller banks have been clients of top dealers on these platforms, enjoying low transaction costs in major currencies while making markets in local currencies. The rise of electronic execution has enabled algorithmic trading, particularly on multi-bank platforms such as EBS and Reuters. In particular, one type of algorithmic trading, high frequency trading, has been an important source of growth in activity since 2004. The survey also showed increased participation by retail investors through online retail aggregators, this type of trading is usually known as margin trading. It is also important to note that there have been developments that have led to reduced activity in the market, the most important of which is the internalisation of trading by large banks (King and Rime, 2010).

The 2013 survey confirmed the trends identified in previous surveys. The increase in activity between 2010 and 2013 was the result of the growing role of non-dealer institutions, a further increase in the role of emerging market currencies, and changes in market structure due to technological developments. During this period, the role of non-dealer institutions as liquidity providers became more visible (Rime and Schrimpf, 2013). In 2016, for the first time since 2001, global FX turnover declined between two consecutive surveys. Spot trading fell by 19% between 2013 and 2016, as global trade and capital flows declined as a result of diverging monetary policies in key regions. The composition of traders changed in favour of risk-averse investors, and the activity of hedge funds and principal trading firms had declined. However, Moore et al. (2016) argue that the trading activity of non-dealer institutions shifted away from high-frequency trading towards more passive strategies based on market making. The rebound in activity from 2016 levels, and the further increase seen in the 2019 survey, is the result of an increase in activity by hedge funds and principal trading firms due to the increased risk-taking capacity of financial markets. In particular, there has been a recovery in trading by prime brokerage firms in the spot market (Schrimpf and Sushko, 2019). Spot trading activity has increased by about \$120 million from

2019 to 2022, amid exceptionally volatile conditions in the FX market due to changes in the future path of interest rates for major currencies, rising commodity prices, and geopolitical risks. Two major structural trends identified in the 2022 triennial survey are the migration of FX trading to less visible venues and increased trading activity in emerging market currencies (McGuire et al, 2022).

The changes in market activity in the FX market and the factors behind them, both structural and short-term market factors, are discussed above through the lens of the BIS Triennial Surveys and accompanying articles. The following section elaborates on the structural changes mentioned above.

There have been two major developments that have gone hand in hand: (1) the electronification of FX markets, (2) the increasing participation of non-dealer financial institutions. As mentioned above, Thomson Reuters Matching was introduced in 1992 and EBS followed Reuters. By the end of the 1990s, interdealer trading was dominated by these electronic brokerage platforms. The share of these two major ECNs increased from 10 percent in 1995 to 50 to 70 percent in 2001 and was around 32 percent in 2007 before falling to 13 percent in 2016. The share of the major ECNs in total turnover decreased from 16 per cent to 9 per cent in 2022 due to increased trading activity in other venues, especially on single-bank platforms (Drehmann and Sushko, 2022).

Table 2.1
Share of Major Electronic Computer Networks in FX Trading

This table represents the percentage share of electronic computer networks (Reuters Matching and EBS) in spot and total FX trading. The values are based on accompanying studies published in the relevant year's BIS Triennial Surveys.

	1995	1998	2001	2007	2010	2013	2016	2019	2022
Spot Trading	10	40	50-70	32	20-27	16	13		
Total Trading				17	19	14	11	16	9

In the early 2000s, short-term market factors motivated the involvement of non-dealer financial institutions in the FX market. In 2004, high-frequency traders started to use EBS through its newly launched Spot AI facility, and in the following years Reuters offered a similar service. In 2005, the facility was extended to non-dealer financial

institutions through prime brokerage agreements, meaning that institutions such as hedge funds, investment funds, etc. were able to access EBS and Reuters Matching for the first time. (King and Rime, 2010). Thus, in the 2000s, trading on the Reuters Matching and EBS electronic brokerage platforms was not only inter-dealer as in the 1990s, but also included several non-dealer financial institutions with different trading motives and techniques. At the same time, transaction costs fell due to improvements in trade processing and settlement systems and increased competition between electronic platforms, making more trading strategies profitable and encouraging speculative activity. These developments encouraged the entry of new participants into the FX market, which are very heterogeneous in terms of their trading motives, patterns, horizons and the size of their positions. These non-dealer financial institutions include hedge funds and other leveraged investors with large trading sizes, lower tier banks, pension funds, mutual funds and high-frequency trading firms, and their share of the market increased from 20 per cent in 1998 to 55 per cent in 2019. Starting with major currencies, this trend reached previously less liquid currencies, especially emerging market currencies (Rime and Schrimpf, 2013).

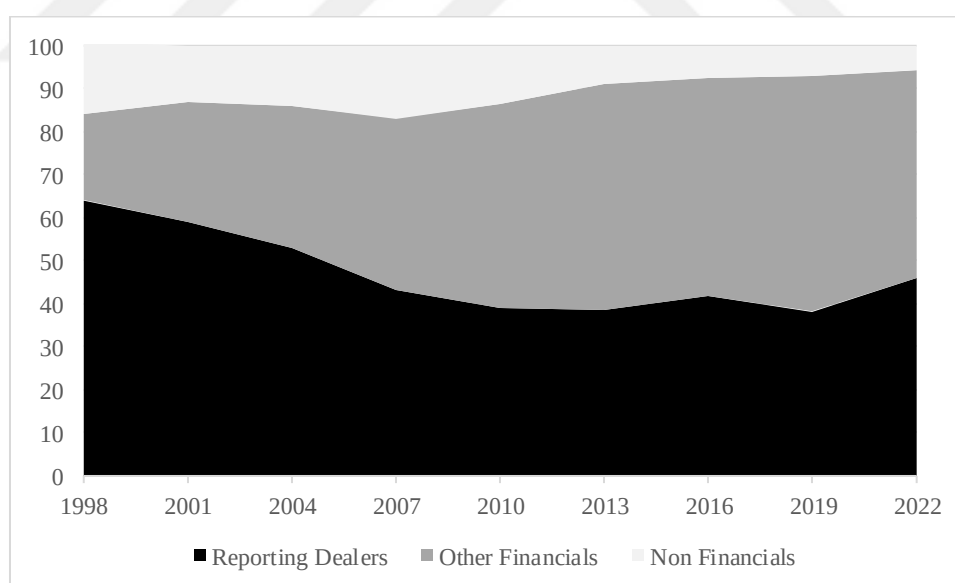


Figure 2.2 Share of Market Players in the FX Market This figure represents the percentage share of dealer institutions, non-dealer institutions and non-financial market players in the FX market. The data are based on BIS Triennial Surveys.

Among non-bank institutions, algorithmic traders in particular have boosted trading volumes on ECNs and have become dominant in ECN trading. The share of

algorithmic trading on EBS was less than 5 per cent in 2004, while it more than doubled in the following three years, reaching over 75 per cent in 2019, with a steady increase over the years (Schrimpf and Sushko, 2019). One type of algorithmic trading, high-frequency trading (HFT), had a particular impact on the functioning of ECNs and the structure of the FX market. Major ECNs became active trading platforms for HFT. However, the profit margin of HFT decreased as the number of high-frequency traders increased and HFT firms started to provide liquidity in addition to engaging in pure price arbitrage (King and Rime, 2010). In 2016, for the first time in history, non-bank institutions appeared in the ranking of Euromoney magazine. Currently, non-bank institutions are active in market making and providing liquidity in the FX market. The market share of proprietary trading firms in electronic trading with buy-side clients increased significantly from 10 per cent in 2016 to 32 per cent in 2019 (Schrimpf and Sushko, 2019). With these structural changes, the distinction between dealer and non-dealer financial institutions is becoming less apparent, making it more difficult to characterise the behaviour of different counterparties (Galati and Heath, 2007).

Not only banks, but also non-dealer institutions providing liquidity in the interdealer market, reduced the profitability of this market for banks. Banks also faced the risk of adverse selection by the HFT firms actively trading on the major ECNs (BIS Markets Committee Report, 2018). Banks responded by developing proprietary platforms (single bank platforms), which allowed them to transact electronically with their clients. With single bank platforms, banks aimed to meet the needs of a wide range of customers, from small corporate customers to sophisticated financial institutions. This development opened up opportunities for counterparties who had not previously had access to electronic brokerage systems, and expanded the client base for electronic trading. In parallel with the development of single-bank platforms, multi-bank electronic trading systems such as Currenex, FX Connect and FXall were established in the early 2000s to meet client demand for prices from multiple sources (Galati and Heath, 2009).

After 2010, there was a significant shift from indirect trading via multi-bank trading platforms to direct electronic trading. Banks upgraded their single-bank platforms to

offer different services to different client segments. In addition, as major ECNs introduced speed bumps in 2013, some proprietary trading firms also started to trade electronically directly with clients through their prime brokerage arrangements by 2015. As a result, relationship-driven trading has gained significant importance in FX trading. In parallel, trading volumes on the major ECNs have declined (Moore et al, 2016). The 2022 survey showed that dealers' response to structural changes in the FX market by investing in single-bank platforms has paid off; the share of dealer banks in total turnover increased from 38 percent in 2019 to 46 percent in 2022, with a corresponding increase in the share of direct electronic trading at the expense of major ECNs. Across all these different trading platforms, the share of spot turnover traded electronically increased from around 40 percent in 2008 to over 70 percent in 2016 (BIS Markets Committee Report, 2018). The 2022 survey found that around 60 percent of all FX trades are executed electronically. Drehmann and Sushko suggest that the process of electronification may have stabilised, as the relative shares of voice and electronic execution in the FX market have not changed over the past three years (Drehmann and Sushko, 2022).

An important consequence of the development of electronic trading methods and the increasing participation of non-dealer institutions in the FX market has been the internalisation of dealer trading. As banks reached a wider client base through single and multi-bank platforms, their transactions with clients increased, allowing them to match more trades on their books internally and capture the bid-ask spread. This internalisation of trades reduced the dominance of banks on the main ECNs (Reuters Matching and EBS). The share of this platform in total turnover decreased in parallel with the increase in volume on other electronic platforms and the corresponding increase in internalisation of trades. As shown in Table 1, the share of these platforms in spot trading decreased from 50-70 percent in 2001 to 13 percent in 2016. Similarly, King and Rime (2010) suggest that the internalisation rate of top dealers was less than 25 percent in 2007, while it increased to over 80 percent in 2010. Moore et al (2016) show that the internalisation ratio is highest in the spot segment, and is above 60 percent in a volume-weighted sense. In parallel, the share of interdealer trades in FX turnover has steadily declined from above 60 percent in 1998 to below 40 percent in

2019 (Schrumpf and Sushko, 2019). The internalisation of trades has important implications for the functioning of FX markets. First, it reduces the need to hedge risk and reduce inventory balances through the inter-dealer market, leading to a reduction in hot potato trading. Second, as more trades are managed internally on banks' books, fewer trades are visible in the broader market, leading to less information leakage (Butz and Oomen, 2019). Third, as mentioned above, it reduces trading in primary venues, which played a crucial role in price discovery. However, the BIS Markets Committee Report (2018) discusses that these venues are still vital to the functioning of the FX market and still serve as important venues for price discovery, as dealers still need these venues to manage inventory imbalances when volatility increases and internalisation becomes more difficult.

As discussed above, in today's market structure, there are two vendors. This creates a new form of "hot potato" trading where dealers are no longer at the center. Positions are also held by fewer institutions. The current structure is more fragmented in terms of trading platforms and methods and participants, but more concentrated in terms of positions being held by fewer institutions. The average number of banks covering 75% of FX turnover has almost halved between 1998 and 2019, falling from 13 to 7 (Schrumpf and Sushko, 2019).

Another consequence of the development of electronic trading methods and the increasing participation of non-dealer institutions in the FX market is the concentration of trading venues. Two main developments have led to the high concentration of trading venues. The first is the widespread use of prime brokerage arrangements, which are typically offered by large dealers in London or New York. The second is the rise of algorithmic trading as HFT requires co-location near the main servers of electronic platforms, which are usually located in London or New Jersey due to speed advantages (Rime and Schrumpf, 2013).

In parallel with these developments, the role of emerging market currencies in the FX market has increased. Turnover in EM currencies grew faster than overall turnover for several periods after 2004, reflecting market factors such as attractive risk-adjusted

returns on EM currencies and increased international portfolio diversification, as well as structural factors such as lower trading costs due to the development of electronic trading methods. The participation of non-dealer institutions in EM currencies has also increased significantly as a result of the market and structural factors mentioned above. The electronification of trading and the increased participation of non-dealers meant more offshore trading, where both counterparties are located outside the currency issuing jurisdiction (Schrimpf and Sushko, 2019). Patel and Xia (2019) discuss that the rapid expansion of offshore trading has both advantages and disadvantages. Offshore trading can increase liquidity, reduce transaction costs that would expand market participants, and increase foreign investment and trade in goods and services. However, they also stress that offshore trading can influence the price discovery process in markets that are more difficult for central banks to monitor than onshore markets. Their analysis of four NDF currencies shows that there is a bidirectional relationship between onshore and offshore markets in normal times, but that offshore venues tend to drive movements in times of global market stress.

All in all, today's FX market structure is very different from the traditional two-tier market structure that prevailed before 2000, with separate inter-dealer and customer-dealer segments. Today's FX market is fragmented in the sense that there are multiple trading platforms, most participants are connected in more than one way, and liquidity providers are not only dealers but also non-dealer institutions, a very diverse group with different trading motivations and techniques. The degree of internalisation among dealers is high and dealers are no longer dominant in trading via the main ECNs, which are widely used by algorithmic traders. On the other hand, the FX market is concentrated in terms of large dealers and institutions providing liquidity. Trading is also more geographically concentrated. The high degree of internationalisation and the existence of several direct/indirect trading platforms have led to a trading environment where trading information is private. Today's FX trading environment, which is very different from the traditional one, with less "visible" trading and greater market fragmentation, has several important implications for the price discovery process and market functioning.

CHAPTER 3

PRICE DISCOVERY IN FOREIGN EXCHANGE MARKETS

Price discovery, defined as the process by which markets find equilibrium prices (Schreiber and Schwartz, 1985), is the focus of market microstructure research. Market microstructure analyses the behaviour and formation of prices in asset markets. Fundamental to this approach is the belief that features of the particular trading mechanisms used in markets are important in influencing the behaviour of asset prices. (Easley and O'hara, 2003). This line of research emerged with the first direct analysis of the nature of transaction costs by Demsetz (1968), and expanded significantly after the 1987 market crash, which revealed the fragility of markets. According to the market microstructure approach, any trading mechanism can be seen as a kind of trading game in which players meet in a certain place and act according to certain rules. Thus, the microstructure literature focuses on three main dimensions of the trading process, namely the market participants, such as customers, dealers, brokers or market makers; the trading venues, such as exchanges, computerised trading networks; and the market rules. (O'hara, 1998). The first models in the microstructure literature were inventory-based models, which view the trading process as a matching problem in which the market maker must use prices to match supply and demand over time. The later models were information-based models, which viewed the trading process as a game involving traders with asymmetric information and the trading process as a learning problem faced by market participants.

The emergence of the market microstructure approach and the models developed later were initially based on the equity market and pricing in equity markets. The market microstructure approach to the FX market began about a decade later. After the abandonment of fixed exchange rate regimes in the 1970s, economists developed

models that were inductively constrained by the lack of data. The first model, purchasing power parity, was useful in explaining long run movements but not in explaining short run movements. The next generation of models, covered and uncovered interest rate parity, failed to predict short-run exchange rate movements better than a random walk. In the mid-1980s, researchers began to design models using a "facts first" approach, visiting dealing rooms. Surveys revealed three beliefs that were widely held in the market, but which were significantly at odds with standard exchange rate models. First, FX dealers believed that exchange rates responded to trade flows. Second, FX dealers considered private information to be an important feature of the market. Third, FX dealers believed that private information influences exchange rates through trade flows. In the absence of high-frequency data on FX trading in the 1970s and 1980s, when trades were executed by telephone and fax, it was not possible to systematically study the microstructure of the market. But in the 1990s, with the availability of high-frequency data sets and data sets from major ECNs, researchers were able to analyse the market more systematically.

All three of the dealer beliefs described above have been confirmed by econometric tests and validated dealer beliefs (King et al., 2013). Thus, the first studies to understand the functioning of the markets were related to order flow and the effect of order flow on exchange rates. First, the definition of order flow was set to buy, focusing on the initiator of the trade. In the FX microstructure, order flow is measured as the number of trades initiated by buyers minus the number of trades initiated by sellers (King et al, 2013). The first evidence on how order flow affects exchange rates comes from Lyons (1995). Using data from a single dealer, he finds that this dealer would increase its quotes by 0.0001 Deutsche Mark (DEM) for incoming orders worth \$10 million. Extending this research from a single dealer finding to a study of the whole market, Evans and Lyons (2002) show that there is a strong positive relationship between order flow and contemporaneous returns using interdealer order flow over four months of transactions in USD-DEM and USD-JPY in 1996. Evans and Lyons (2002) show that the explanatory power of order flow for contemporaneous returns is higher when returns are allowed to respond to order flow in other currency pairs. The causal relationship between order flow and returns is supported by several other

empirical findings (Evans and Lyons, 2005; Killeen et al., 2006, Daniélsson and Love (2006)).

The results of the studies on the relationship between order flow and returns suggest that some of the order flow has a persistent impact on FX returns. Evans and Lyons (2005) show that the impact of order flow on returns persists for up to one week. Other studies show that the persistence of the effect can last longer (Killeen et al., 2006, Berger et al., 2008). To explain the persistent effect of order flows on exchange rate returns, the literature has focused on three theories. The first theory focuses on dealers' inventory management, the second assumes a finite price elasticity of asset demand, and the third is based on private information. Thus, the market microstructure literature developed along these axes. Researchers developed theoretical models to explain the pricing process in the FX market based on different assumptions.

In this chapter, we first review the models that explain the pricing process in the FX market. We then review important empirical evidence on private information, liquidity, heterogeneity of market participants and market microstructure in the FX market. Next, we review the types of data in the FX market. Finally, we focus on the comparison of indicative and tradable quotes in the literature.

3.1 Theoretical Microstructure Models of FX Market

Unlike equity markets, where trades are executed at a publicly quoted price and all traders in the market have the same trading opportunities, an interesting question would be how price formation evolves in the FX market, where trades and prices are fragmented across different platforms and different types of market participants.

One of the earliest models is developed by Lyons (1997), which aims to explore the microstructure of the FX market by developing a model that explains the behaviour of FX dealers and the "hot potato" trading process in the FX market. The model focuses on how FX dealers manage their inventories and the strategic interactions that drive price movements and trading volumes in the interdealer market. In this 2-period model, there are several risk-averse FX dealers trading simultaneously. Dealers adjust their

quotes and trading strategies to manage their inventories. They aim to maintain a balanced position to avoid the risk of holding a large open position. Dealers also have private information about their own holdings, which influences their trading behaviour and their quotes. The model shows how prices in the FX market are affected by dealers' inventory positions and how important this is for the price formation process. As dealers adjust their quotes to manage their inventories, these adjustments contribute to price formation in the market. The model also shows that this trading process leads to higher trading volumes and short-term volatility in the market. In the model, as traders trade with each other, information about market conditions and inventories is gradually revealed and incorporated into prices. Thus, the model highlights the role of interdealer trading in disseminating information. Lyon's (1997) model provides a detailed explanation of interdealer trading in the FX market and the model offers fruitful insights into the microstructure of the FX market, including how prices are formed, the role of inventory control and the impact of private information on trading behaviour. The model suggests that the FX market is efficient in the sense that prices quickly reflect inventories and private information. However, the hot potato trading process can also lead to temporary price distortions and increased volatility.

Evans and Lyons (2002) develop an FX trading model that captures several important features of FX market structure. King (2013) defines this model as the intellectual workhorse of the microstructure field. In this model, dealers start each trading day with zero inventories and there are three rounds of trading. In round 1, dealers quote prices, execute trades from random customers, and accumulate inventory. In round 2, dealers trade with each other, effectively redistributing the aggregate inventory among dealers. In Round 3, dealers return to their preferred zero overnight inventory position by selling their inventory to a second set of customers. In the model, Round 1 and Round 2 customers are defined as non-dealer public customers, but they differ in terms of their trading motivations. The trading demand of Round 1 customers is based on portfolio shifts and can be viewed as a demand for liquidity from dealers in response to exogenous shocks to their desired currency holdings. Thus, they effectively demand overnight liquidity from the market as a whole, as they permanently change their currency holdings. Dealers are assumed to be reluctant to provide overnight liquidity

as they prefer to have zero overnight holdings. Consequently, dealers change their quotes sufficiently to induce other customers to buy their remaining holdings at the end of the day. These clients are Round 3 clients, whose motivation is defined as non-stochastic and purely speculative. Thus, the appreciation of a currency in response to a positive order flow from round 1 clients depends on the elasticity of demand for round 3 currency. In effect, Round-3 customers provide overnight liquidity to the market while demanding immediate liquidity from their dealers. Evans and Lyons (2002) discuss that in the traditional approach based on macroeconomic determinants, information is incorporated into exchange rates without the need for order flow as it is common knowledge. However, empirical evidence shows the explanatory power of order flow. If some of the information in the market is not common knowledge, or if some aspect of the mapping from information to equilibrium prices is not common knowledge, then order flow is said to convey information about market-clearing prices. Thus, this model resolves the contradiction by assuming that information about shifts in public demand is not common knowledge and that traders acquire this information by observing order flow. As they learn, they quote prices that reflect this information. The 3-round model of Evans and Lyons (2002) has important implications for the modelling of short-run exchange rate dynamics. First, it emphasises the importance of finitely elastic currency demand. Second, it highlights the role of heterogeneity among clients.

In their 2005 study, Evans and Lyons built upon their earlier model to gain insight into end-user order flow and demonstrate that the price impact of flows from different customer segments varies. It is important to note that the theory assumes that agents are symmetrically heterogeneous, meaning that they can differ in any given aspect but in a uniform manner. However, trades in the FX market originate from categories of customers that are markedly disparate in terms of their motivations, risk attitudes and time horizons. The authors demonstrate that order flow provides market-makers with timely information about the state of the macroeconomy in a setting where there is end-user heterogeneity. They illustrate that the types of customers affect the information content of order flow and emphasise that order flows provide more precise and timely information to dealers when the pool of customers is more forward-looking

and keener to react to private information.

Cao et al. (2006) builds upon the Evans and Lyons (2002) model by incorporating two rounds of interdealer trading into the trading day, effectively transforming it into a four-round trading process. In the initial round, dealers engage in transactions with customers requiring liquidity, which is subsequently followed by a round of interdealer trading. In this phase, dealers monitor the order flow resulting from interdealer trading. Subsequently, a second round of interdealer trading is permitted, during which dealers may engage in speculation based on non-fundamental information pertaining to market-wide inventory imbalances. In the final stage of the trading process, dealers engage in transactions with liquidity-supplying customers, thereby assuming a risk-sharing role within the broader market. Ultimately, the dealers conclude each trading day with a zero net risky position. The authors acknowledge that information-based trades may still occur in a market where all participants have access to the same fundamental information. The introduction of inventory information as non-fundamental data demonstrates that it continues to serve as a catalyst for speculation, as it is found to be correlated with future price movements.

The preceding overview focuses on models developed exclusively for the FX market. These models aim to capture the market characteristics while demonstrating that order flow is a significant factor in price formation within the context of the trading process. In the following section, we will discuss models that have been developed exclusively for the FX market. However, rather than focusing on the characteristics of the market itself, we will concentrate on the processes of price discovery, the bid-ask spread, and adverse selection.

In the classical microstructure models based on a one-tier market, adverse selection is the dominant factor influencing the bid-ask spread (Glosten and Milgrom, 1985; Holden and Subrahmanyam, 1992). Market makers incur losses when trading against more informed customers. Consequently, market makers tend to quote higher bid-ask spreads when they can identify more informed customers. In one-tier markets, it is typical for spreads to widen as trade size increases (Peterson and Sirri, 2003).

Nevertheless, given the fragmented nature of the FX market and the existence of multiple trading environments, it is not possible to apply this theory directly to the FX market. In two-tier markets, such as the FX market, dealers may be able to generate indirect gains in the second tier of interdealer trading by leveraging the information gathered from customers in the first tier. Consequently, dealers may be motivated to provide narrower spreads to informed customers in the initial tier. It may therefore be surmised that adverse selection will have a negligible impact on the bid-ask spreads of the first tier.

The objective of the Osler et al. (2011) study is to present a comprehensive account of the pricing processes in FX markets. To this end, the authors distinguish between two market segments, namely the customer and the interdealer market, with specific reference to the processes of price discovery. The authors posit that price discovery in FX markets occurs in three stages that are parallel to the two-tier structure of the FX market. The model further posits that private information is generated by a subset of customers. The FX market comprises numerous dealers engaged in interactions with customers and with one another in an interdealer market. In the initial stage, a dealer engages in a transaction with an informed customer, thereby acquiring an indication of the customer's private information. Nevertheless, in this phase, the dealer does not widen the spread, as the informed customer pays a narrower spread than uninformed customers. Therefore, the private information has no impact on the trade price at this stage. In Stage 2, the dealer engages in a bold trade in the interdealer market, leveraging the private information to generate profits, which in turn shifts the bid-ask spread. It is therefore anticipated that price discovery in the interbank market will adhere to the established paradigm. In Stage 3, prices are based on interdealer quotes, thereby reflecting the new information. This marks the conclusion of the price discovery process. Empirical evidence lends support to this three-stage model of price discovery. Osler et al. (2011) demonstrate that dealers typically engage in aggressive trading following the execution of informed customer trades. Goodhart and Payne (1996) and Menkhoff (2010) demonstrate that dealers update their quotes in accordance with the most recent observed trade, thereby facilitating the incorporation of new information into price formation. The authors demonstrate that this response is

less pronounced for informed dealers, as they have less to learn from the trades of others. Conversely, less informed dealers may even reverse the direction of their trades in order to align themselves with the more aggressive dealers, who are perceived to possess superior information.

The model developed by Osler et al. (2011) provides a comprehensive framework for understanding price discovery in the FX markets. The model provides an explanation of the process by which quotations are updated in accordance with the trading activities of informed market participants. The model has significant implications. Firstly, the model suggests that order flow is a significant conduit for price discovery, aggregating dispersed private information and incorporating it into the prices. Secondly, the model suggests that the price on one platform may lead or lag the other due to the presence of different trader groups on each platform. Finally, the model suggests that the primary platform for price discovery is the interdealer trading platform, with information subsequently flowing to the dealer-customer segment.

The preceding overview of microstructure models pertaining to the FX market structure has identified several such models. These models collectively demonstrate the significance of order flow, private information, and the impact of market participant heterogeneity in determining exchange rates. They offer a comprehensive understanding of the microstructure mechanisms that underpin the price discovery process. The following section presents a synthesis of significant empirical findings pertaining to the price discovery process in the FX market.

3.2 Empirical Findings on Price Discovery

Empirical research has identified a number of key mechanisms through which price discovery occurs, thereby underscoring the inherent complexity of this process. The extant literature identifies several key factors that are important to understand this complex process. These include order flow, private information, liquidity, the types of market players involved and issues related to market microstructure in the FX markets. The following section will present a review of the critical findings in this area, based

on the aforementioned factors.

3.2.1 Private Information in the FX Market

As previously stated, several studies have demonstrated the persistence impact of order flow in the literature. One of the explanations put forth for this phenomenon is the existence of private information. This explanation is based on the argument that the trading flows aggregate dispersed private information that is relevant for pricing exchange rates. Nevertheless, the role of private information in FX markets has been called into question, given that the majority of exchange rate fundamentals, such as interest rates and general price levels, are publicly disclosed.

A number of studies have provided evidence that is consistent with the presence of private information. The term "private information" is used in different ways in the context of FX markets. Sources of private information that have been the focus of microstructure literature include central bank intervention, fundamental variables, and non-fundamental information such as inventory levels.

A number of findings have been published concerning the relevance of private information on the fundamentals. In their 1997 study, Peiers investigated the price leadership patterns of the Deutschmark against the USD. Their findings revealed that Deutsche Bank exhibited price leadership up to 60 minutes prior to interventions by the Bundesbank. Ito et al. (1998) demonstrate that following the implementation of trading during the lunch hour, post-lunch trading variance is amplified due to the acquisition of private information by dealers during this period. Covrig and Melvin (2002) demonstrate that the contribution of Japanese quotes to the discovery of the yen/dollar price is greater when informed market participants are active. Evans and Lyons (2012) investigate whether order flows convey fundamental information. They demonstrate that transaction flows can forecast future macroeconomic variables, including output growth, money growth, and inflation, using end-user currency trades received at Citibank over a 6.5-year period. Rime et al. (2010) employed one year of high-frequency data from Reuters for three major exchange rates, demonstrating that order flow is associated with current and expected macroeconomic fundamentals. Furthermore, it predicts daily movements in exchange rates. Menkhoff and Schmeling

(2010) demonstrate that informed traders typically execute trades using medium-sized orders, have considerable trading volume, are situated in a financial center, trade at the outset of the trading session, during periods of wide spreads and when the order book is thin.

Conversely, the findings of Cai et al. (2001) indicate that customer order flow resulting from portfolio shifts exerts an influence on exchange rates, even when accounting for macroeconomic announcements and central bank intervention. Additionally, the findings of Dominguez and Panthaki (2006) demonstrate that non-fundamental news and order flow are significant determinants of exchange rates. This evidence suggests that non-fundamental information also plays a role in price discovery.

3.2.2 Liquidity and Price Discovery in the FX Markets

Probably the two most significant functions of financial markets are the provision of liquidity and the discovery of prices (King et al., 2013). The extant literature indicates that market liquidity is priced in the cross-section of FX returns, a finding that is consistent with the results observed in the equity markets (Menkhoff et al., 2012; Banti et al., 2012; Mancini et al., 2013).

The extant literature on equity markets indicates that liquidity, proxied by bid-ask spreads, is influenced by a number of factors, including volatility, the expected time between trades, adverse selection risk, the rate of information arrival, trade size and dealers' risk aversion (Ho and Stoll, 1981; Glosten and Milgrom, 1985). The results of the analysis of interdealer spreads indicate that the aforementioned effects are also present in the FX market. The evidence suggests that interdealer spreads increase in line with trading volumes and volatility (Bollerslev and Melvin, 1994; Hartmann, 1998; De Jong et al., 1998; Melvin and Yin, 2000). Additionally, interdealer spreads have been observed to widen during periods of elevated political and social risks, such as riots and armed attacks, as well as during periods of heightened uncertainty. (Melvin and Tan, 1996; Mende, 2006; Kaul and Sapp, 2006). Conversely, findings related to the change in interdealer bid-ask quotes in response to inventory shifts do not align with the standard theory, which posits that dealers shade their quotes to avoid

disclosing information on their inventory levels. Bjornnes and Rime (2005) present evidence that dealers do not engage in the practice of 'shading' their quotes with the intention of concealing their inventory levels. Instead, they demonstrate a tendency to unload their inventory with considerable rapidity within the interdealer market.

The literature demonstrates that spreads of dealers to customers, in contrast to the interdealer spreads, do not corroborate the prediction of the standard models. As discussed in the preceding section, which focused on theoretical models, the two-tier structure of the FX markets presents a contrasting picture. When there is private information, the interdealer market spreads widen, while for the most informed FX customers, the spreads charged to informed customers are narrower (Osler, 2011). It can be inferred from market practices that dealers promote their substantial inventory positions to informed customers at narrower bid-ask spreads, with the objective of clearing their inventory positions without trading in the interdealer markets.

Additionally, a body of literature exists which examines the influence of liquidity on the effect of order flows on prices. In times of high liquidity, Payne (2003) demonstrates that the permanent order flow effect is diminished in comparison to periods characterised by a scarcity of liquidity. Berger et al. (2008) demonstrate that the correlation between interdealer order flow and exchange rate returns is more pronounced when market liquidity is at its lowest. This provides compelling evidence that liquidity effects are indeed a significant factor.

3.2.3 Heterogeneity of Market Participants in the FX Markets

The FX market comprises a multitude of market participants, a consequence of its considerable size, global reach and the diverse needs and strategies of those involved. As discussed in Chapter 2, dealers play a pivotal role in the functioning of this market. They provide liquidity to customers, manage inventories, and take speculative positions. Central banks and governments participate in order to manage or stabilise their currencies, whereas companies engage in the market with the objective of trading currencies for international trade, thereby hedging against currency movements. In addition, financial institutions, commercial banks, and asset managers play a

significant role in the market, seeking to capitalise on exchange rate movements. Exchange rate models in the FX market encompass the characteristics of the principal participants in this market. Hedge funds are analogous to the archetypal rational investor, engaging in trading on the basis of proprietary exchange-rate forecasts and driven by the twin objectives of profit and risk. Exporters and importers, in contrast, engage in currency purchases (sales) following a depreciation (appreciation) in value and refrain from engaging in speculative trading (King et al., 2013). The existing literature demonstrates that the diversity of market participants is manifested in their impact on order flows, the possession of private information, and consequently, the price discovery process. The following section presents a brief overview of the key findings from the literature.

In their 2007 study, Carpenter and Wang demonstrate that the identity of market participants affects the information content of FX transactions. The results demonstrate that central banks, which exert the greatest influence on price, are followed by non-bank financial institutions, including hedge funds and mutual funds. The trades of non-financial corporations are found to exert the least impact. Furthermore, the study reveals that in the interbank market, dealers with more exclusive information tend to favour direct trading, which is less transparent, over trading platforms.

Simon and Heimer (2011) demonstrate that, on average, retail investors incur financial losses. Nolte and Nolte (2012) demonstrate that individual investors rely on previous price movements when making future investment decisions, yet they do not anticipate future returns. This evidence suggests that retail FX traders provide liquidity by behaving in a manner similar to noise traders. Bjønnes et al. (2005) demonstrate that financial order flow Granger-causes corporate order flow, while the reverse relation is not valid. This implies that the primary liquidity providers in the overnight FX market are non-financial customers. The findings of Marsh and O'Rourke (2005) demonstrate that corporate order flow responds negatively to lagged returns, whereas financial order flow does not respond to lagged returns. This implies that corporate customers provide overnight liquidity, while financial customers demand liquidity.

3.2.4 Market Microstructure and Price Discovery in the FX Markets

The detailed mechanics and processes through which currency transactions occur are closely connected to the price discovery in the for FX markets. The preceding sections have discussed a number of factors. In addition to the aforementioned factors, the trading systems, geographical factors and regulatory environment also play a pivotal role in the price discovery process. In recent years, the advancement of trading platforms and structural changes in the market with regard to trading technology have had a significant impact on the formation of prices in the FX market. Furthermore, technological advancements have impacted the velocity of this process. The following section provides a concise overview of the factors that have influenced the formation of prices.

The advantages of electronic systems, as outlined by Barker (2007), include the ability to process transactions more rapidly and accurately, reduce operational costs, eliminate geographical restrictions, lower the barriers to market entry, and enhance market transparency. It can therefore be assumed that the aforementioned advantages will lead to an increase in liquidity in FX markets (Ding and Hiltro, 2010). However, there is a divergence of opinion on this matter. Researchers such as Pagano and Roell (1996), Naik et al. (1999) and Flood et al. (1999) posit that the operational advantages, inventory risk and information costs inherent to the new systems should result in narrower spreads. However, experimental findings by Bloomfield and O'Hara (1999, 2000) suggest that dealers with informational advantages may widen the spreads to compensate for the loss of information advantage due to increased market transparency. Consequently, the electronic systems may even dissuade dealers from participating in trading, thereby impairing market liquidity. Ding and Hiltro (2010) conclude that the positive effects outweigh the negative, and that electronic systems overall enhance FX market liquidity. The results demonstrate that the EBS has the effect of reducing overall spreads and eliminating geographical differences in market liquidity. Conversely, their study substantiates the assertion that dealers with an informational advantage tend to quote relatively wider spreads with the new systems. In their study, Chaboud et al. (2021) examine the evolution of the price discovery

process on the EBS platform. Furthermore, the study indicates that price discovery occurs more rapidly, which suggests improvements in market efficiency. Furthermore, the results indicate a notable reduction in the proportion of information conveyed by market orders, particularly in comparison to manual orders. The proportion of information conveyed by market orders from algorithmic and high-frequency traders is observed to remain constant.

A review of the literature reveals that the speed of the price discovery process has also undergone a transformation. In their study, Carlson and Lo (2006) found that the 1997 fundamental news shock was incorporated into prices within a period of approximately half a minute. The advent of algorithmic trading has led to the conjecture that the market's reaction to new information may now be substantially faster (Chaboud et al., 2009; King et al., 2012). The utilisation of algorithmic trading by participants in the FX market has increased significantly over the past decade. By dividing larger trades into smaller transactions through the use of execution algorithms, institutional investors employ trading algorithms to manage their trade flows in a more intelligent manner. Chaboud et al. (2009) demonstrate that algorithmic trading is associated with reduced volatility in high-frequency data, suggesting that algorithmic trading is linked to greater liquidity.

The FX market is open 24 hours a day and operates in a multitude of time zones and locations across the globe. Given the varying levels of activity and the presence of different market participants in different time zones and locations, it is evident that trading volume, liquidity and market behaviour will differ from one area to another.

D'Souza (2007) demonstrates that trades are more informative when initiated in major foreign exchange centers like London and New York or in a local country. This suggests that there are informational asymmetries based on geography with regard to the market-making capacity of dealers and customer order flow. In their 2011 study, Moore and Payne investigate the source of information advantage in inter-dealer FX trading. They find that dealers who trade most frequently and specialise their activity in a particular rate have an informational advantage in liquid dollar exchange rates.

Conversely, those engaged in triangular arbitrage are better informed with regard to cross-rates. Furthermore, the study demonstrates that traders with superior information are situated on larger trading floors. Wang and Yang (2011) demonstrate that price discovery in the foreign exchange markets is still predominantly influenced by European and US trading hours, particularly the overlapping trading hours in London and New York. In a study published in 2013, Gençay and Gradojevic demonstrated that region-specific private information is a primary factor in explaining the variation in currency returns. Furthermore, the evidence suggests that the rounds of trading conducted in the early morning and late afternoon GMT periods are associated with the highest risk of informed trading.

In addition, institutional factors may have an impact on the price discovery process in the foreign exchange markets. Nevertheless, there is a lack of academic research on this topic. A comprehensive and intriguing study was conducted by Rime and Tranvag (2012). Utilising a 15-year data set encompassing 11 Asian and Australasian currencies, encompassing both highly liquid currency pairs and less liquid currency pairs, as well as currencies operating under disparate monetary regimes, the authors identify that the impact of order flow on currency returns is most pronounced in the context of floating exchange rates. However, this impact is also considerable in the context of other exchange rates, particularly during periods of market turbulence.

3.3 Data in the FX Market

The fragmented market structure of the FX market, coupled with the lack of transparency in trading, presents a significant challenge in terms of accessing data. In such a fragmented environment, it is not feasible to access all trading data; consequently, the data utilized in research represent a limited subset of the trading activity.

In accordance with the conventional two-tier structure of the market, Lyons (2001) classified the data sets into three categories. The initial group comprises data on customer and dealer trades, the second group encompasses data on direct interdealer trades, and the third group includes data on brokered interdealer trades. Obtaining data

on customer and dealer trades is challenging due to the confidential nature of these transactions. Financial institutions are not legally required to disclose such information (Lyons, 2001). The data set typically encompasses all executed customer-dealer trades at a single financial institution over a specified time frame. This category of data provides insight into the trading process, albeit from a narrow perspective of the market. Additionally, Lyons (2001) considers EFX indicative price data as a further type of data within this group. This data set comprises best bid and ask quotes, the identity of the quoter and the city in which the quoter is based. However, it does not include any trades or trade prices. It should be noted that the quotes are indicative and therefore not committed prices for trading. Lyons (2001) posits that these prices are provided for non-dealer customers to furnish real-time information regarding the prevailing prices. Consequently, he categorises this data within the initial group. The second group of data sets pertains to direct interdealer trades. The data sets pertaining to the third group encompass data sourced from electronic broking systems. The data set encompasses the most advantageous bid and ask quotes, along with the corresponding trade prices (and, in most cases, the quantity traded). It should be noted that the quotes displayed on the platforms are subject to trades. Consequently, these prices are not indicative, but rather represent firm prices. Furthermore, the data can be employed in order flow analysis, given that it encompasses trade quantity. However, the data set lacks information regarding the identity of the quoter and the identity of the counterparties involved in the transaction. Lyons (2001) posits that this data set offers the advantage of reflecting the activities of multiple dealers trading simultaneously.

The structure of the FX market has undergone a significant transformation, evolving from a two-tier market to a considerably fragmented one. This has made it challenging to identify data sets that accurately represent the majority of trading activity. Consequently, data can be grouped into three main categories. The data can be grouped into three main categories: data from major ECNs, indicative data from data vendors, and proprietary data gathered from single or multi-bank platforms.

Given that ECNs adhere to a standard closed-order book, they effectively function as

an exchange, with the gathered quotation data serving to establish a firm (tradeable) price. Typically, the data set comprises the best bid price, the best ask price, the traded price, and the trade quantity. However, these data are not publicly accessible. The second category of data comprises that which is provided by data vendors. The data most frequently utilised is that sourced from the EFX page of the Reuters Platform. EFX was the primary source of foreign exchange price information for dealers for approximately a decade (King et al., 2012). The EFX data set comprises indicative quotes, which are prices posted by banks that are not necessarily committed to trading at those prices. However, they are generally expected to do so (Goodhart and O'Hara, 1997). These prices are primarily used as a marketing tool to demonstrate the bank's market presence (Phylaktis and Chen, 2009). It is commonly held that the provision of these prices by dealers is an attempt to attract customer business. Lyons (2001) posits that these prices are provided for non-dealer customers to furnish them with real-time information regarding the prevailing prices. This perspective is supported by Goodhart and O'Hara (1997). It is proposed that, as market makers (banks) are typically privy to the prevailing quotes, end-users of indicative quotes are often non-bank entities, such as non-bank companies and public sector bodies, which may not possess the same level of market intelligence. However, King (2012) suggests that the EFX prices have enhanced transparency in the FX market by functioning as a comprehensive repository of up-to-date price information from numerous dealers. Additionally, Martens and Kofman (1998) assert that indicative quotes on the EFX page provided by Reuters constituted the sole information source accessible to all traders globally. One advantage of this data set in comparison to data from electronic trading systems is that it includes the identity and the city of the quoting bank. This allows researchers to explore the heterogeneity of market participants (Lyons, 2001; Phylaktis and Chen, 2009).

3.4 Market Fragmentation and Price Discovery

As market fragmentation gains pace, it becomes increasingly important to examine the extent and direction of price discovery. It is of great importance to ascertain which market is the first to incorporate new information regarding the asset in question.

Furthermore, it is crucial to gain an understanding of how the trading mechanisms, market liquidity and the prevalence of asymmetric information effects the efficacy of price discovery in order to gain insight into the price discovery process in a market.

This issue has been the subject of extensive study with regard to stock markets based on cross-listed stocks in multiple markets. The studies examine not only the market in which price discovery occurs, but also the potential reasons for this. To illustrate, Eun and Sabherwal (2003) employ a sample of Canadian/US cross-listed firms and ascertain that the proportion of the US market is directly correlated with the proportion of trading in the US market and the ratio of informative trades on the US and Canadian exchanges. Conversely, this is inversely related to the ratio of bid-ask spreads. Similarly, Frijns et al. (2010) examine Australian-New Zealand cross-listed firms and conclude that the home market plays a dominant role in price discovery, with a negative correlation between price discovery and the percentage spread. Similarly, Frijns et al. (2015) demonstrate that lower relative spreads and higher relative trading activity result in an exchange's greater contribution to price discovery, as evidenced by data on Canadian firms cross-listed on the primary US stock exchanges. The issue is also studied in other types of markets. For example, Chen and Tsai (2017) examine the relationship between the VIX and VIX futures and demonstrate that an increase in the futures basis between the VIX and VIX futures results in an increase in the contribution to price discovery made by VIX futures. Papavassiliou and Kinatader (2021) investigate the location at which price discovery occurs for euro-denominated sovereign bonds and demonstrate that no specific market dominates the price formation process across all maturity segments.

A number of studies have been conducted on price discovery in relation to other markets, particularly the stock market, as previously discussed. However, this topic remains under-researched in the context of the FX market. The initial studies were conducted following the advent of electronic trading systems and focused on analysing the price discovery process between indicative and tradeable quotes from primary trading venues. Goodhart et al. (1996) employ a data set comprising seven hours of observations for the DM/USD currency pair and 16 minutes of observations for six

other currencies. Their findings indicate that the time series characteristics of prices are similar across both indicative and tradeable quotations from the Reuters system. However, they also reveal significant differences in the distribution of bid-ask spreads between these two categories of quotations. Danielsson and Payne (2002) demonstrate that price discovery primarily occurs in firm quotes using five days of data from October 1997 for the DM/USD currency pair. Their findings indicate that over 90% of relevant information initially enters into firm quotes and subsequently impounds into indicative quotes. However, Phylaktis and Chen (2009) employ four months of data for DM/USD and GBP/USD between May and August 1996 and ascertain that the information share of indicative quotes is approximately 80%. Furthermore, they determine that indicative data possesses a higher information value when there is a considerable increase in the transaction frequency in trades within the matching system. The extant literature contains a number of studies that have specifically addressed this issue. However, the results of these studies are not entirely consistent with one another.

CHAPTER 4

DATA AND METHODOLOGY

This chapter describes the data collection process and presents the methodology used in the analyses. Section 4.1 provides information about the data and Section 4.2 explains the calculation of the price discovery measures.

4.1 Data

The dataset covers two different series of currency prices for the period between 10 August and 30 November 2020, capturing almost 4 months of tick-by-tick data for 16 different currency pairs. The currency pairs included in the sample represent majority of the currencies that trade in the Reuters Matching Platform Exchange rates that are actively traded are in the Reuters Matching platform are included in the sample, while currency pairs that are known to be dominantly traded in the EBS platform are excluded. The sample covers nearly all of the currencies in the top 30 based on their daily turnover in the BIS Triennial Survey of 2019.

Data on indicative quotations have information on quotation time, best bid, best ask, name of the quoter and city of the quoter. Data on tradeable quotes have information on quotation time, trade price, trade flag, best bid, best ask, mid-price and flag for the triggering side of the trade. All time stamps are based on Greenwich Mean Time (GMT). In the sample, some exchange rates represent the price of 1 USD in another currency like USD/MXN and USD/TRY; some exchange rates represent the price of 1 unit of a currency in USD like GBP/USD and AUD/USD. The quotations retrieved from the platforms are not changed to follow pricing conventions in the market.

Table 4.1 shows the number of trades, the number of quotes, and, the trade ratio, which

is a ratio of number of trades to number of quotes, for each currency pair. As a first step filter, currency pairs whose trade ratios that are smaller than 0.10 are excluded from the sample since the comparison of tradeable quotes with indicative quotes would be meaningful only if tradeable quotes are subject to frequent trading. Thus, USD/CHF, USD/CZK, USD/SEK, USD/RUB, USD/PLN, USD/NOK, USD/HUF are not included in the final sample.

Table 4.1
Tradeable Data Counts

This table presents the total number of trades (# of Trades), total number of quotations (# of Quotes), and the trade ratio (Trade Ratio) calculated as the ratio of total number of trades to total number of quotations for each currency pair during the sample period. Currency pairs with their abbreviations are also shown.

Currency Pair	Abbreviation	# of Trades	# of Quotes	Trade Ratio
Australian Dollar / US Dollar	AUD/USD	357,991	1,661,592	0.22
British Pound/ US Dollar	GBP/USD	207,879	1,273,672	0.16
New Zealand Dollar/US Dollar	NZD/USD	106,874	605,989	0.18
US Dollar/ Canadian Dollar	USD/CAD	158,298	855,960	0.18
US Dollar/ Swiss Franc	USD/CHF	718	589,532	0.00
US Dollar/ Czech Koruna	USD/CZK	1,300	2,929,525	0.00
US Dollar/ Turkish Lira	USD/TRY	50,039	104,411	0.48
US Dollar/ South African Rand	USD/ZAR	62,227	499,166	0.12
US Dollar/ Thai Baht	USD/THB	88,646	111,485	0.80
US Dollar/ Singapore Dollar	USD/SGD	103,643	485,782	0.21
US Dollar/ Swedish Krona	USD/SEK	9,528	1,959,631	0.00
US Dollar/ Russian Ruble	USD/RUB	5,351	3,940,046	0.00
US Dollar/ Mexican Peso	USD/MXN	120,880	1,116,138	0.11
US Dollar/ Polish Zloty	USD/PLN	4,860	3,342,141	0.00
US Dollar/ Norwegian Krone	USD/NOK	9,950	3,520,942	0.00
US Dollar/ Hungarian Forint	USD/HUF	1,874	5,220,614	0.00

Next, weekends and bank holidays for each country in the currency pairs are filtered. As a third step, quotes with missing bids, asks, and negative or zero spreads are excluded. Finally, duplicate data with the same time stamps are removed. In addition, consecutive bid and ask differences are calculated in order to remove any outliers that arise from erroneous data entry.

In order to take into account the intraday seasonality in the spreads and trading activity (more information on intraday seasonality is given in Chapter 5 under Preliminary Findings), the day is divided into 8 equal slices. Table 4.3 shows the time slices with

their corresponding time periods.

Table 4.2
Indicative and Tradeable Quote Counts

This table presents the number of quotations that remain in the sample after each filtering step. Filter -1 removes weekends and holidays, Filter-2 removes missing bids and asks, Filter-3 removes negative or zero spreads, and, Filter-4 removes quotes with the same time stamps. Panel A shows the counts for indicative quotes. Panel B gives the counts for tradeable quotes. Ratio is the number of tradeable quotes divided by the number of indicative quotes (multiplied by 100).

Panel A: Indicative Quotes						
	Unfiltered	Filter-1	Filter-2	Filter-3	Filter-4	
GBPUSD	11,250,527	10,213,870	10,213,870	10,213,870	10,200,176	
USDCAD	7,145,928	6,714,918	6,714,918	6,714,918	6,710,084	
USDTRY	12,248,105	11,191,205	11,191,205	11,191,205	11,076,272	
USDZAR	14,858,879	13,706,994	13,706,994	13,706,994	13,640,349	
AUDUSD	6,355,834	5,900,342	5,900,342	5,900,342	5,893,796	
NZDUSD	3,119,271	2,778,252	2,778,252	2,778,252	2,773,037	
USDMXN	7,116,719	6,571,609	6,571,609	6,571,609	6,569,332	
USDSGD	1,378,501	1,314,565	1,314,565	1,314,565	1,310,393	
USDTHB	169,672	156,487	156,487	156,487	156,486	
Panel B: Tradeable Quotes						
	Unfiltered	Filter-1	Filter-2	Filter-3	Filter-4	Ratio (%)
GBPUSD	1,481,551	1,366,622	1,366,583	1,366,355	1,366,355	13.4
USDCAD	1,014,258	954,950	954,934	954,621	954,621	14.2
USDTRY	154,450	139,331	139,303	131,188	131,188	1.2
USDZAR	561,393	503,471	503,451	503,146	503,146	3.7
AUDUSD	2,019,583	1,904,988	1,904,968	1,904,477	1,904,477	32.3
NZDUSD	712,863	639,836	639,809	639,602	639,602	23.1
USDMXN	1,237,018	1,165,352	1,165,328	1,162,582	1,162,582	17.7
USDSGD	589,425	534,211	534,172	532,319	532,319	40.6
USDTHB	200,131	184,427	184,408	176,683	176,683	112.9

Table 4.3
Time Slices

This table shows the time slices used in the analyses with their corresponding time periods in Greenwich Mean Time.

Time Slice	Time Period
1	00:00-02:59
2	03:00-05:59
3	06:00-08:59
4	09:00-11:59
5	12:00-14:59
6	15:00-17:59
7	18:00-20:59
8	21:00-23:59

4.2 Methodology

Lehmann (2002) defines price discovery as the “efficient and timely incorporation of the information implicit in investor trading into market prices”. Classical market microstructure assumes that a given security trades in a single centralized market. In the foreign exchange market, on the other hand, trading is fragmented and dispersed to several platforms. Such a structure raises the question of which one of the markets incorporates new information first and thus takes the leadership. In order to answer this question, several price discovery measures were developed in the literature. The first of the two commonly used measures is the information share measure developed by Hasbrouck (1995). The second one is the component share measure, developed by Booth et al. (1999), Chu et al. (1999), and Harris et al. (2002) based on the work of Gonzalo and Granger (1995).

Studies conducted on this subject before the work of Hasbrouck (1995) and Gonzalo and Granger (1995) use the lead-lag return regressions to examine price discovery in different trading platforms. However, the lead-lag relationship may capture only transitory fluctuations which are not information related because it is not capable of distinguishing between transitory and permanent changes in prices.

Hasbrouck (1995) argues that the implicit efficient price is common to all markets, and the sources of variation in this efficient price are attributed to different markets. So, he claims that price discovery in this framework refers to the innovations in the efficient price and defines information share as a market's contribution to price discovery, which is calculated as the proportion of the efficient price innovation variance that can be attributed to that specific market.

In contrast, Booth et al. (1999), Chu et al. (1999), and Harris et al. (2002), adopting the permanent-transitory decomposition technique in Gonzalo and Granger (1995), focus on the composition of the efficient price innovation and measure a market's contribution to price discovery by the component share of that market in forming the efficient price innovation. In addition to these measures, Putnins (2013) proposes the

information leadership measure based on the work of Yan and Zivot (2010). This measure uses the information share and the component share measures together to identify the price series that is first to impound the new information.

The following subsections provide a detailed description of each of the three price discovery measures.

4.2.1 Information Share Measure

Following the representations of Elder et al (2014), assume a price vector of $P_t = [P_{1,t}, P_{2,t}]'$, where P_1 and P_2 refer to the time series of a security's two prices observed in two different markets. The cointegration of prices implies that they may be represented in a vector error correction model (VECM) of order K :

$$P_t = \alpha\beta'P_{t-1} + \sum_{k=1}^K \mu_k \Delta P_{t-k} + u_t \quad (4.1)$$

In Equation 4.1, P_t is a vector of prices, α is the error correction vector that measures the speed of adjustment to the error correction term, $\beta = (1, -1)'$ is the cointegrating vector, μ_k are matrices of autoregressive coefficients, and u_t are innovations with a constant variance Ω . The VECM model has two parts: the first part, $\alpha\beta'P_{t-1}$, represents the equilibrium dynamics between the price series, and the second part, $\sum_{k=1}^K \mu_k \Delta P_{t-k}$ depicts the short-term dynamics induced by market imperfections. This model can be represented as an integrated vector moving average process:

$$P_t = \psi(1)\sum_v^t u_v + \psi^*(L)u_t \quad (4.2)$$

In Equation (4.2), $\Psi(1)$ is the sum of moving average coefficients $\Psi(1) = (1 + \Psi_1 + \Psi_2 + \dots)$, and $\Psi^*(L)$ is a matrix polynomial in the lag operator (L). The first expression in this equation measures the long run impact of an innovation in prices, and represents the common factor component among the price series. The second expression $\Psi^*(L)$ is transitory, and therefore, measures the temporary influence on prices. Hasbrouck (1995) defines the information share of a price series as the

proportion of the variance in the common price process that is attributable to that particular price series. Defining a row of $\Psi(1)$ as ψ , the IS for the i 'th time series is defined as follows:

$$IS_i = \frac{\psi_i^2 c_{ii}}{\psi \Omega \psi'} \quad (4.3)$$

In Equation 4.3, C is the lower triangular Cholesky factorization of Ω . The Cholesky factorization orthogonalizes the variance in the common price process that is attributed to each innovation, but it is dependent on the arbitrary ordering of the price series in the VECM. Thus, the result is an estimate of IS_i that is not uniquely defined.

As an alternative, the upper and lower bounds of IS_i are calculated by applying the Cholesky factorization to all possible orderings. Baillie et al. (2002) find that the mean IS from across all orderings is a reasonable estimate of the contribution of that price series to price discovery.

4.2.2 Component Share Measure

Following the representations introduced above, the following can be written:

$$\Delta P_t = \alpha \beta' P_{t-1} + \sum_{k=1}^K \mu_k \Delta P_{t-k} + u_t \quad (4.4)$$

In Equation 4.4, α is the error correction vector that measures the speed of adjustment to the error correction term. Then, the component share measure is measured as follows:

$$CS_1 = \frac{\alpha_2}{\alpha_2 - \alpha_1}, \quad CS_2 = \frac{\alpha_1}{\alpha_1 - \alpha_2} \quad (4.5)$$

In equation 4.5, α_1 represents the speed of adjustment coefficient of P_1 and α_2 represents the speed of adjustment coefficient of P_2 . Based on Equation (4.5), the component share of a price series is its normalized weight in the linear combination of

prices that forms the common efficient price. Since the speed of adjustment coefficients measure the adjustment to long term equilibrium, they have opposite directions for convergence when they are non-zero, this ensures the non-negativity of component share measures.

4.2.3 Information Leadership Share Measure

Lehmann (2002) discusses that both of the price discovery measures are defined in terms of the reduced form forecasting errors of individual markets from an empirical reduced form vector error correction. However, since the role of each market in the price discovery process depends on the parameters of the structural model, it is very hard to interpret what these metrics really measure. In order to shed a light on this issue, Yan and Zivot (2010) develop a structural cointegration model for asset prices that consist of two price series that are driven by two (one permanent and one transitory) sources of shocks. In this model, the permanent shocks represent innovations in the fundamental value; that is, a one-unit permanent shock leads to a one-unit increase in each of the prices in the long run. On the other hand, the transitory shocks represent noise due to trading frictions, and therefore, a one-unit transitory shock has zero effect on the prices in the long run. The short-run impacts of the permanent and transitory shocks are not restricted by the structural model. Thus, the price series can differ in how quickly they reflect innovations in the fundamental value and how they are impacted by the transitory shocks.

Based on this model, Yan and Zivot (2010) are able to express the information and component share of a price series in terms of its dynamic response to permanent and transitory shocks. Their findings imply that component share is a function of the dynamic response of the price series to the transitory shocks only while information share is a function of the dynamic response of the price series to both the transitory and permanent shocks.

Based on the work of Yan and Zivot (2010), Putnins (2013) proposes a new measure called the information leadership measure. The study shows that information share and component share can be combined in an expression such that the dynamic responses

to transitory shocks cancel out, leaving only a ratio of the price series' dynamic response to permanent shocks. Thus, information leadership share measure is defined as follows:

$$ILS_1 = \frac{IL_1}{IL_1 + IL_2}, \quad ILS_2 = \frac{IL_2}{IL_1 + IL_2} \quad (4.6)$$

In Equation 4.6, IL_1 and IL_2 are defined as follows:

$$IL_1 = \left| \frac{IS_1 CS_2}{IS_2 CS_1} \right|, \quad IL_2 = \left| \frac{IS_2 CS_1}{IS_1 CS_2} \right| \quad (4.7)$$

4.2.4 Comparison of the Price Discovery Measures

The definition of price discovery as the efficient and timely incorporation of information about the fundamental value into the price has two dimensions. The first dimension is timely incorporation of information into prices, which is about the speed. The second dimension is about the efficient incorporation of information into prices, which is about the noise.

Putnins (2013) examines what price discovery metrics really measure by estimating each price discovery metric on simulated data based on a simple structural model that allows price series to differ in noise and the speed of adjustment to new information. The study finds that the information and component share metrics measure the speed with which innovations are reflected in the fundamental price, when the price series that are being compared have similar levels of noise. The study also shows that when the price series have different levels of noise, the component and information share metrics measure the speed with which the prices impound new information as well as the relative avoidance of noise to varying extents. The simulations in the study demonstrate that the information share metric assigns greater weight to speed when compared with the component share metric. Simulation results also show that informational leadership metric values only the speed for impounding new information even in the presence of different levels of noise. Overall, simulations show that the

component share metric values low noise relative to high speed, the information share metric values high speed relative to low noise, and, the information leadership metric values only high speed. The study implies that conclusions regarding previously studied issues, including the role of different asset classes and the types of prices may change substantially depending on the choice of the price discovery metric.

4.2.5 Estimation of the Price Discovery Measures

While examining the price discovery shares of indicative and tradeable quotations, it is critical to consider the discussions on the relative focus of the price discovery measures on the speed and the noise of the series since indicative and tradeable price series are expected to have different levels of noise. Thus, the choice and interpretation of the price discovery metric can have a substantial impact on the conclusions of the study.

Following the discussions above, the three price discovery measures, namely, the component share, the information share and the information leadership share, are estimated. The standard approach of estimating a vector error correction model (VECM) is adopted and the price discovery measures are calculated based on the VECM estimates. The price discovery measures based on the VECM model are calculated as follows:

$$\Delta P_t = \alpha \beta' P_{t-1} + \sum_{k=1}^K \mu_k \Delta P_{t-k} + u_t \quad (4.8)$$

In Equation 4.8, $P_t = [P_{1,t}, P_{2,t}]'$, where P_1 refers to the times series of the indicative mid quotes and P_2 refers to the time series of the tradeable mid quotes. Component share, information share and information leadership shares are calculated parallel to the formulations given above. Elder et al. (2014) argue that high-frequency data enable the information share to be estimated with greater precision. This is in line with Baillie et al. (2002) who argue that the lower correlation of the high-frequency price data allows the model to perform better while attributing the price discovery to a single series. Thus, a sampling frequency of 1-second intervals is used while forming the

price series. It should be noted that a sampling frequency lower than 1 second (e.g. 5 or 10 seconds) makes the estimation of price discovery measures problematic by increasing the residual correlation levels in the vector error correction models, as explained below.

The following steps are followed while estimating the price discovery measures for each time slice (more information on time slices is given in Chapter 5 under Preliminary Findings) with mid quotes sampled at 1-second intervals for each day in the sample: First, the order of integration for log mid prices and change in log mid prices is identified based on the Augmented Dickey Fuller test. Second, cointegration between the log mid prices of the two series is tested based on the Johansen Cointegration test. Third, the series for which the trace test indicates one cointegrating equations at the 0.1 level are selected for analysis. Fourth, the optimal lag structure up to 60 in a vector autoregression model is selected based on the Bayesian Information Criteria. Next, the VECM model as given in Equation (4.8) is estimated with the selected lag. Based on this estimated VECM model, the component share and information share metrics are calculated. As mentioned above, the information share estimates may change when the ordering of the price series is changed. In order to address this issue, the ordering in the VECM model is changed and the information share metric is re-calculated with the alternative ordering.

The final information share metric used in the rest of the analyses are calculated by taking the simple average of the information shares under each of the two possible orderings. Next, the information leadership measures are calculated based on the component and information share metrics obtained in the previous steps. In the final step, estimations where the residual correlation of the VECM is above 0.35 are eliminated, since residual correlations above this level generate information share values that have a wide range of variability. In addition, because tradeable quotations were not frequently updated in 1 second sampling for time slice 8 (21:00-24:00 GMT) vector error correction models could not be estimated for this time slice and excluded from the analyses. Also, the USD/THB estimated are excluded since the VECM residual correlations are very high.

CHAPTER 5

RESULTS AND ANALYSIS

In this chapter, first, the intraday seasonal patterns of tradeable and indicative price series along with their cross-correlations and variances are examined. Next, findings related to the price discovery measures are presented. In the final section, results regarding the determinants of the price discovery contribution of indicative and tradeable quotations are analyzed.

5.1 Preliminary Data Analysis

Reviewing the intraday seasonal patterns provides a preliminary picture of how to handle the analysis considering the intraday seasonal effects. Figure 5.1 shows the intraday graphs of the number of tradeable quotations, number of indicative quotations, number of trades, and indicative and tradeable spreads for each currency pair.

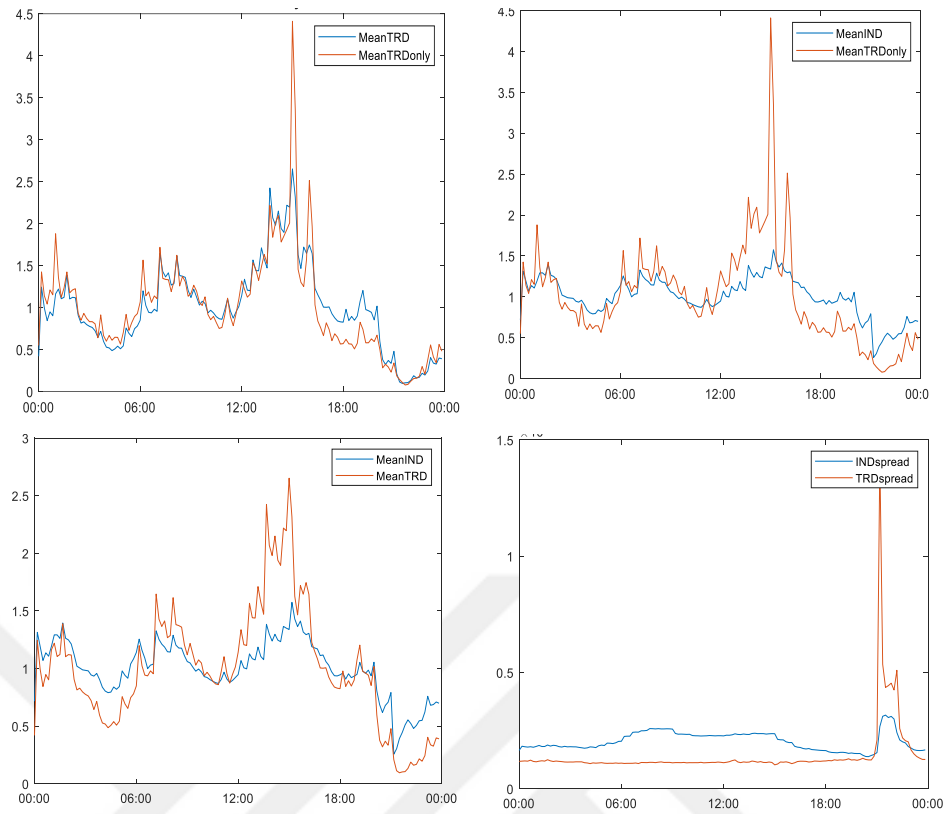
Figure 5.1 demonstrates strong intraday seasonal patterns for all of the currency pairs and the level of activity is high from 6 to 18 GMT, which is a time interval that broadly corresponds to the trading hours of London and US. It is also observed that the number of tradeable quotations is closely related to the number of trades. Moreover, the number of indicative quotations shows intraday seasonal patterns similar to number of trades and number of tradeable quotations. The relationship between the number of indicative and tradeable quotations is found to be strong for AUD/USD, USD/CAD, USD/SGD and NZD/USD. On the other hand, the number of indicative and tradeable quotations seems to be weakly related for USD/ZAR, USD/MXN and USD/TRY. It is also seen that the relationship between indicative and tradeable spreads is weak. Tradeable spreads are higher between 21:00 and 24:00 GMT but they are lower for

other periods except for USD/TRY, USD/ZAR and USD/SGD. A U-shaped spread pattern is observed for most of the currencies, except AUD/USD, USD/CAD, GBP/USD, NZD/USD. In light of the seasonal patterns in trading activity observed in Figure 1 for all currencies, the day is divided into 8 equal slices such that time slice 1 is from midnight to 03:00; time slice 2 is from 03:00 to 06:00, time slice 3 is from 06:00 to 09:00, time slice 4 is from 09:00 to 12:00, time slice 5 is from 12:00 to 15:00, time slice 6 is from 15:00 to 18:00, time slice 7 is from 18:00 to 21:00, and finally, time slice 8 covers from 21:00 to 24:00.

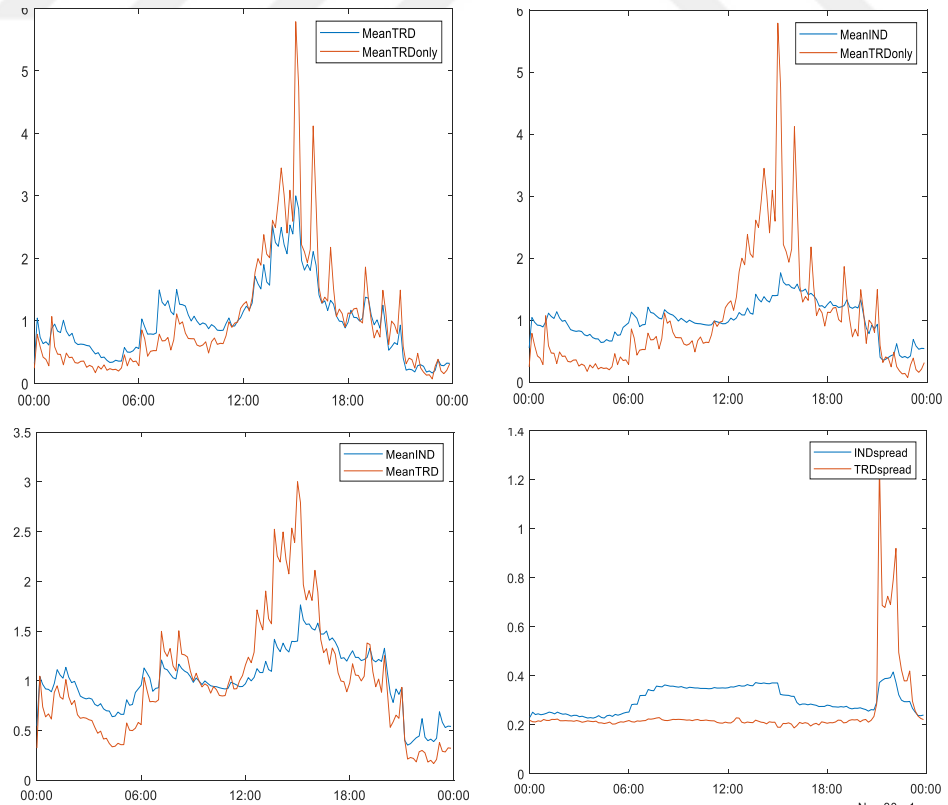
The next step in the preliminary analysis is to understand the relationship between the currency returns calculated based on the tradeable versus indicative prices, by comparing the two return series at different leads and lags. Any significant lead or lag pattern may suggest that one price leads the other in terms of mapping information on to its returns. In previous literature, Danielsson and Payne (2002) use a 20-second sampling frequency and state that this interval is chosen to balance two factors: sampling frequently to maximize the information content of the data and sampling to reduce the number of empty intervals. On the other hand, Phylaktis & Chen (2009) use transaction-time, 5-minute, and, 10-minute sampling alternatives. In order to provide comparable results with the existing literature, return cross-correlations for each currency and time slice are calculated for the sampling frequencies of 3-, 5-, 10-, 30-, and 90-second intervals. For most of the currencies, cross-correlations at one lag are significant for the 5-second and 10-second intervals and for both on- and off-hour time slices. The cross-correlations are not significant for lower frequencies. Correlation levels are generally lower during off-hours. Figure 5.2 presents the cross-correlations between the returns of indicative and tradeable prices based on a 3-second sampling frequency.

As discussed in Chapter 4, the choice of the price discovery metric matters especially when the two series analyzed have different noise levels. In that context, the variance levels of the indicative and tradeable series are analyzed and tested for equality. Table 5.1 shows the variances, statistics of the F-test for the equality of variances and the related p values. The test results show that the variance of the indicative return series is significantly higher than the tradeable return series except for USD/SGD.

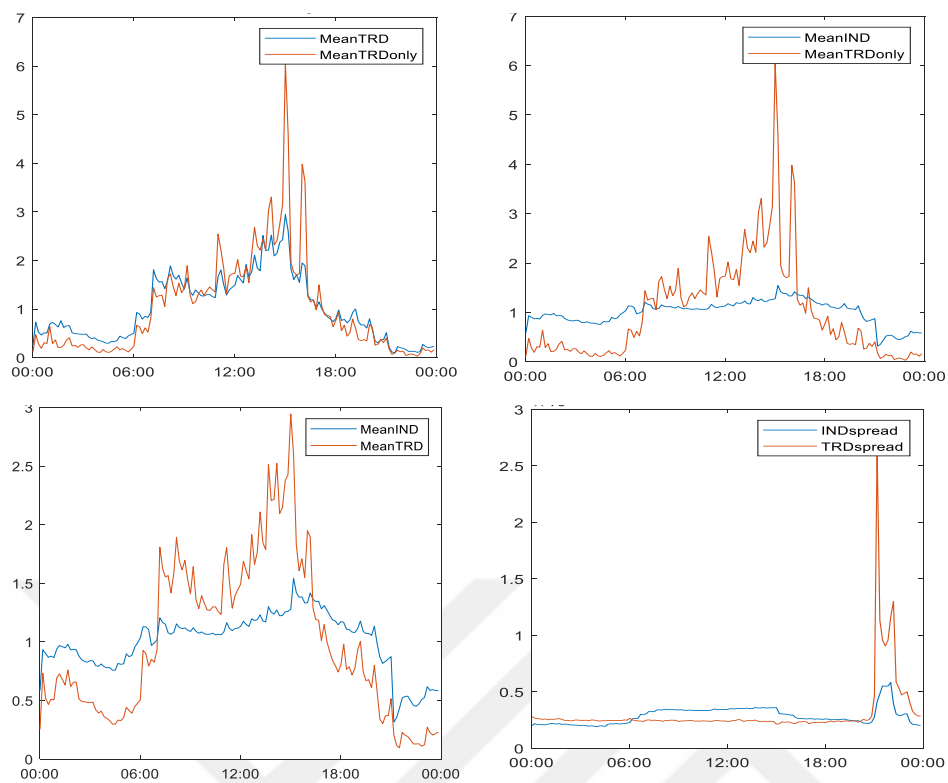
Panel A: Intraday Seasonal Graphs of AUD/USD



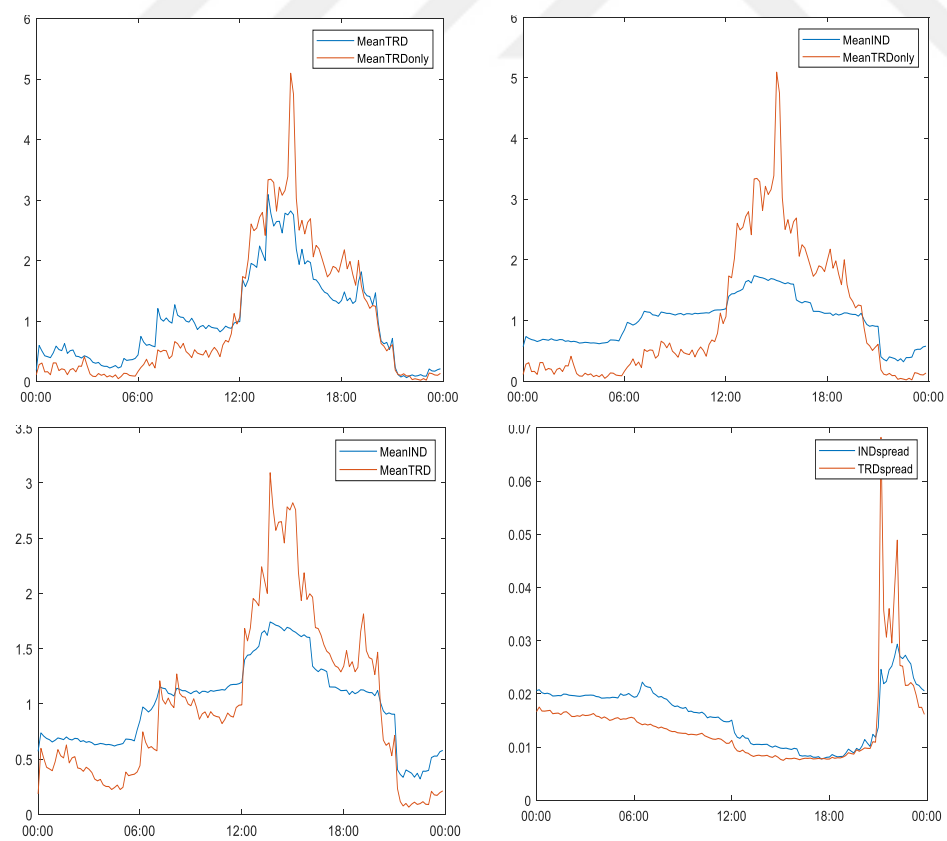
Panel B: Intraday Seasonal Graphs of USD/CAD



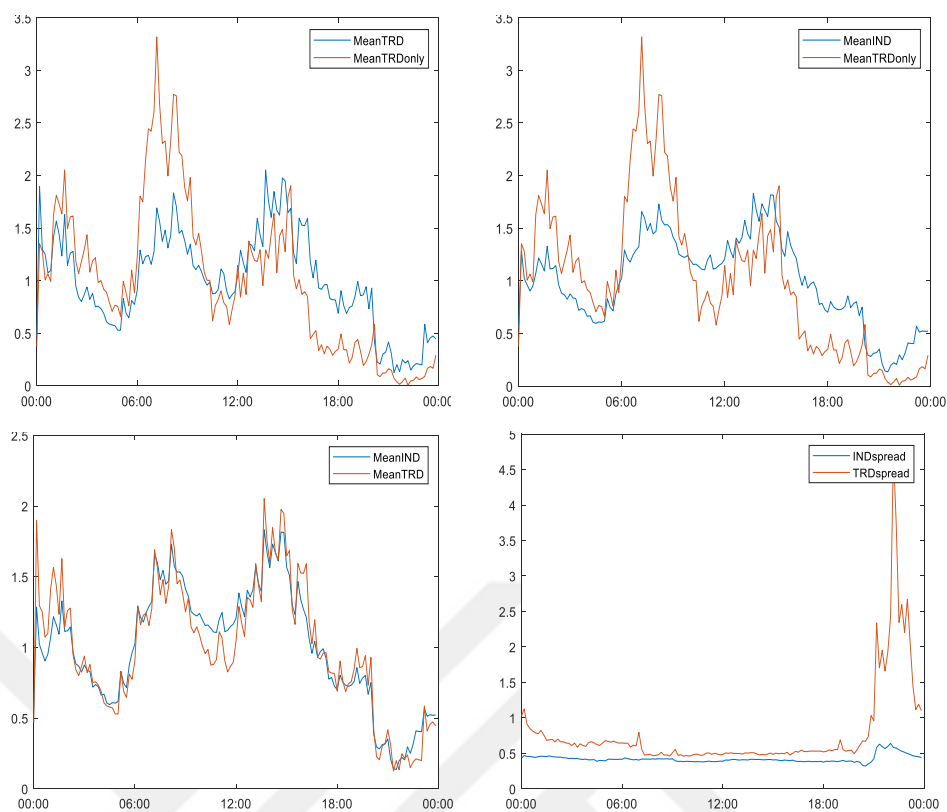
Panel C: Intraday Seasonal Graphs of GBP/USD



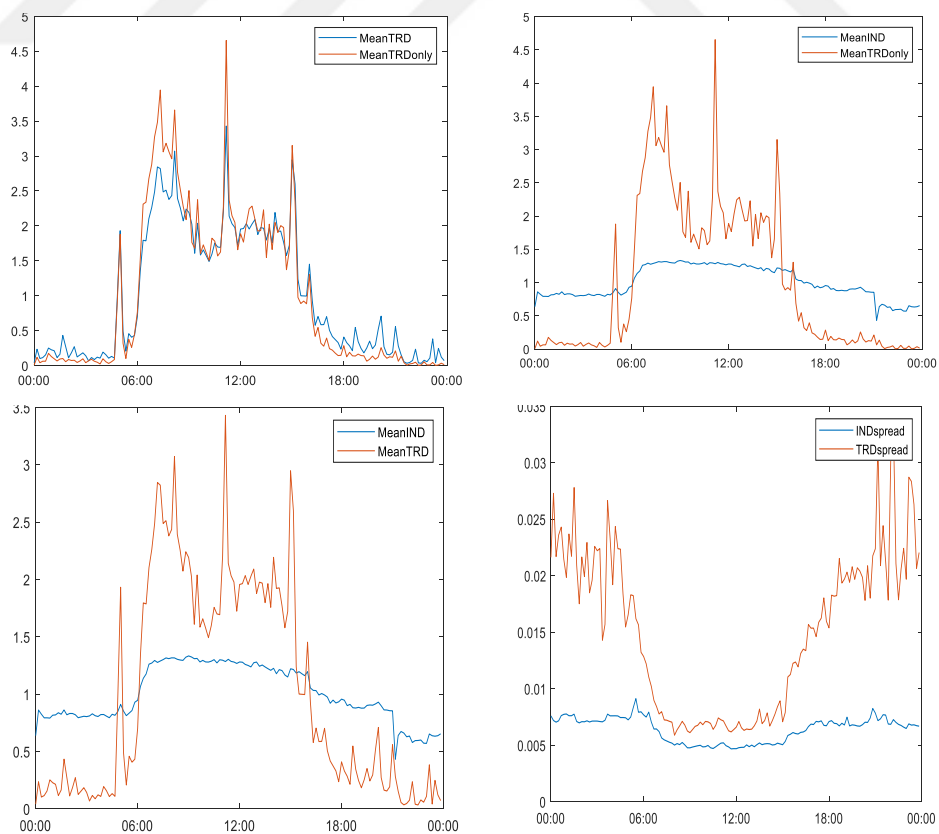
Panel D: Intraday Seasonal Graphs of USD/MXN



Panel F: Intraday Seasonal Graphs of USD/SGD



Panel G: Intraday Seasonal Graphs of USD/TRY



Panel H: Intraday Seasonal Graphs of USD/ZAR

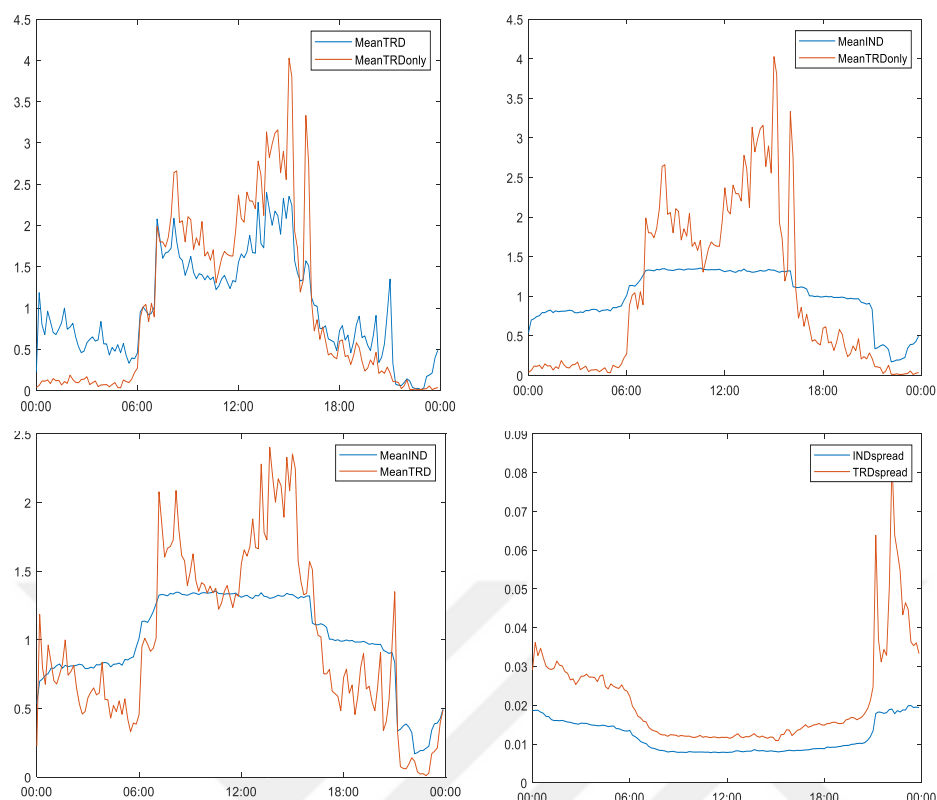


Figure 5.1 Intraday Seasonality The figures show the intraday seasonality patterns in trading activity and spreads for the currency pairs studied. For each currency pair, first, the sum of number of quotations are calculated over 10-minute intervals. Next, the average number of quotations are calculated using the calculations of 10-min intervals from the first step. Next, the average number of quotations for a 10-minute period is divided by the average number of quotations for all periods. Similarly, for the spreads, first, average bid-ask spreads are calculated over 10-minute intervals. Next, average spread is calculated for all periods. Next, the average spread for a 10-minute period is divided by the average spread for all periods. Graphs in this figure show the calculated ratios for each 10-min period. MeanTRD represents the ratio explained above for the sum of number of tradeable quotations. MeanIND represents the ratio explained above for the sum of number of indicative quotations. INDspread represents the average spread for indicative series, while TRDspread represents the average spread for tradeable series. Spreads are multiplied by 1,000 except for MXN/USD, TRY/USD and ZAR/USD.

5.2 Results on Price Discovery Measures

Table 5.2 shows the component, information and information leadership share measures of indicative quotations. Figure 5.3 presents the estimated price discovery measures for each day and trading slice. Since the price discovery measures of indicative and tradeable quotations add up to 1, only the results based on indicative quotations are given. As the price discovery metric measure how much of the new information is reflected first in the related series, the results show that the dominant

location for price discovery is the Reuters matching platform (where the tradeable prices are quoted) in general with significant variation in the currency pairs. On average, the maximum component shares of indicative quotes reach 33% for USD/ZAR followed by 27% for USD/TRY, while the lowest values belong to USD/CAD and AUD/USD with 2% and 5% respectively. The information share measures show similar results as the component share measures. Regarding the information leadership measure, it is observed that the price discovery shares of the indicative quotes reach almost 50% for some exchange rates (USD/ZAR), and for the exchange rates with the lowest component and information share measures, the information leadership measure is above 40%.

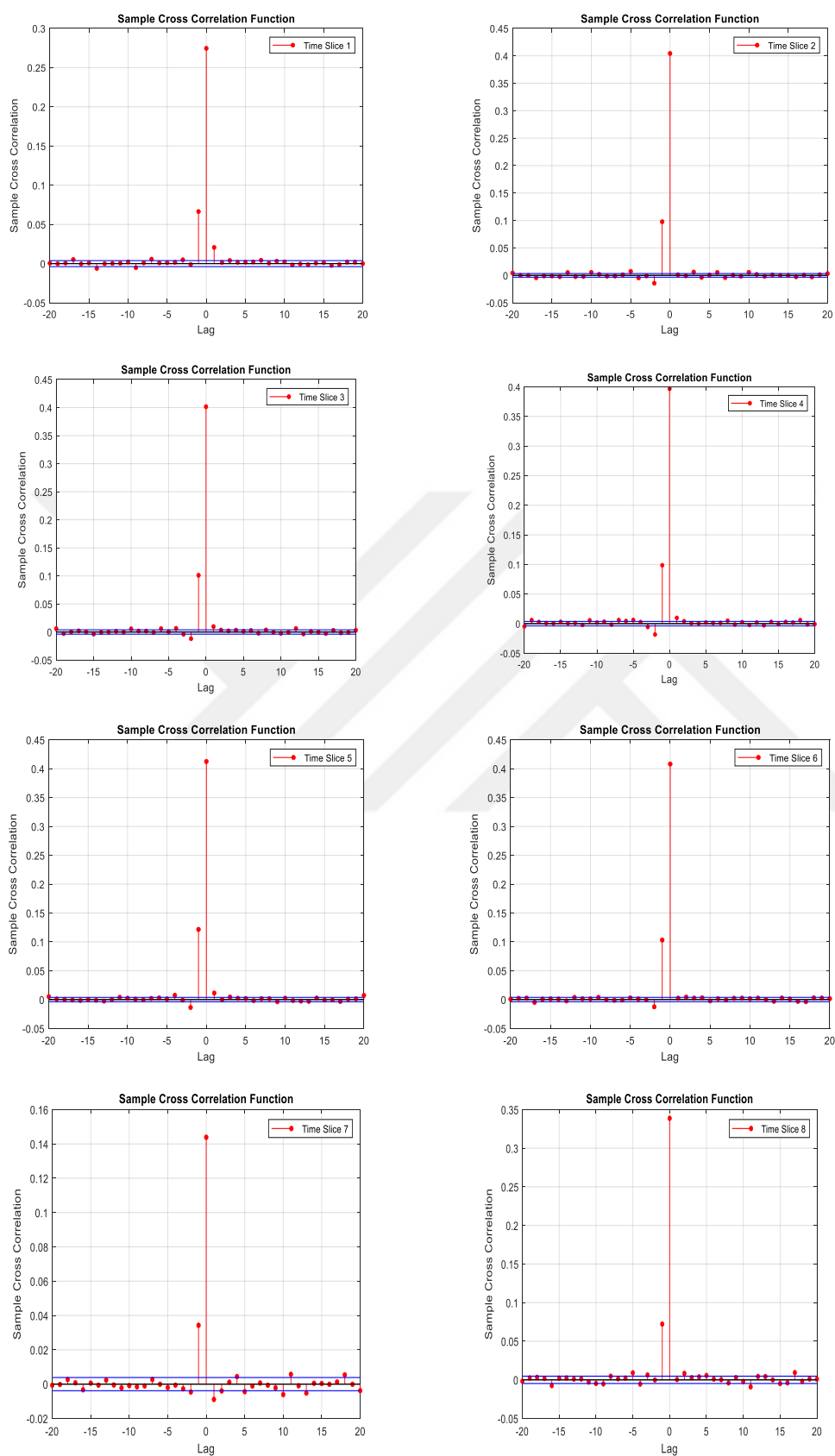
Table 5.1
Variance Levels and Tests of Equality of Variance

This table presents the variance levels of the tradeable and indicative series and F-statistics and p-values for the F-test of the equality of variances. Variances are calculated based on mid quote 1-second returns. TRD Variance represents the variance of the tradeable series while IND Variance represents the variance of the indicative series. Variance values shown are multiplied by 10^6 .

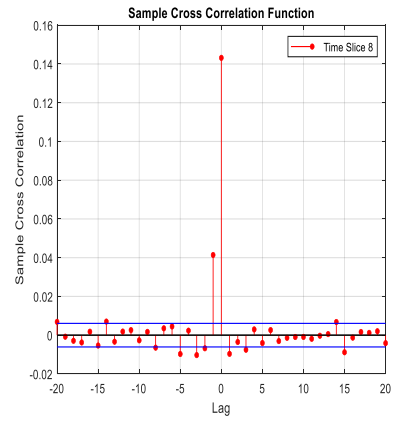
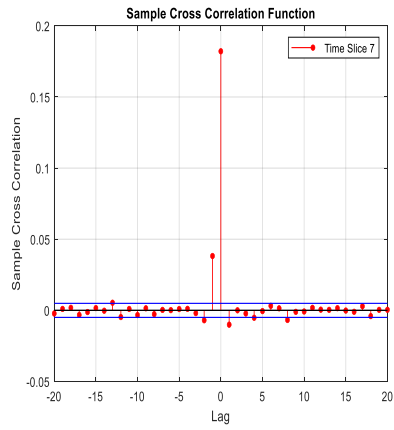
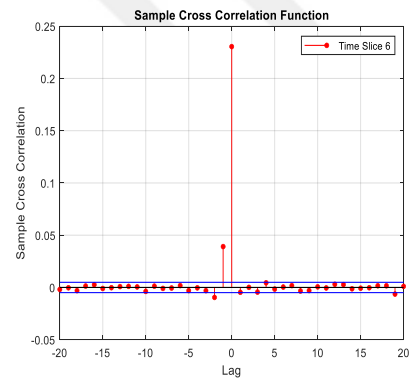
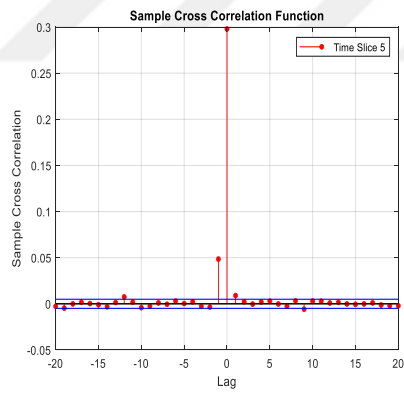
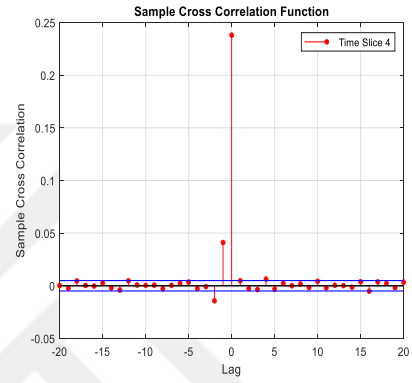
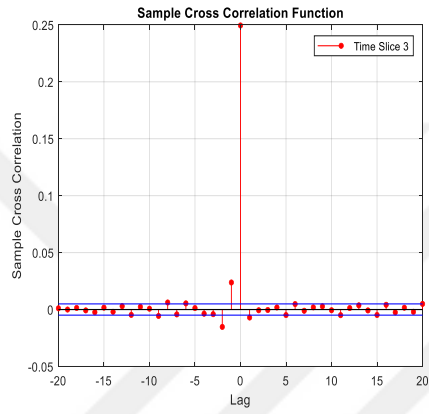
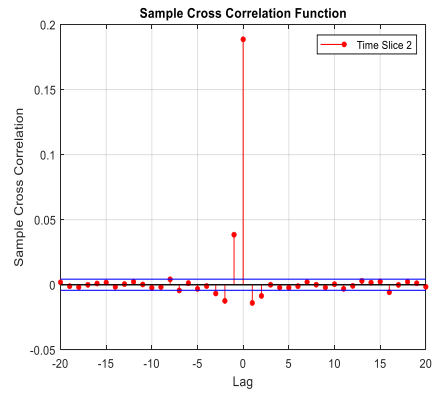
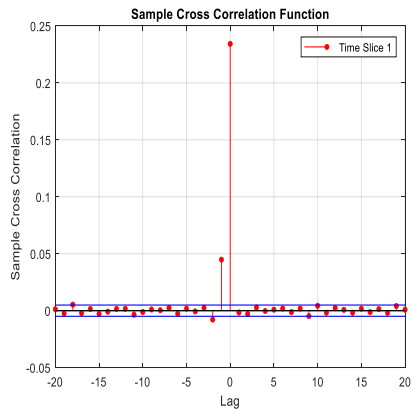
	TRD Variance	IND Variance	F-statistic	P-val
AUD/USD	0.001	0.003	0.3729	0.000
USD/CAD	0.000	0.008	0.0367	0.000
GBP/USD	0.001	0.002	0.3114	0.000
USD/MXN	0.002	0.027	0.0583	0.000
NZD/USD	0.002	0.003	0.5832	0.000
USD/SGD	0.527	0.000	1154.8	0.000
USD/TRY	0.005	0.017	0.2872	0.000
USD/ZAR	0.002	0.005	0.3644	0.000

These findings highlight the importance of the choice of the price discovery measure. Earlier studies on the subject present contradicting results based on the information share measures. Danielsson and Payne (2002) show that for DEM/USD, price discovery takes place predominantly in the firm (tradeable) quotes: over 90% of the relevant information enters into firm quotes first and then it is impounded in the indicative quotes. However, Phylaktis and Chen (2009) find that for DEM/USD and GBP/USD, the information share of indicative quotes is about 80%. The results of this study support the findings of Danielsson and Payne (2002) for the information and component share measures.

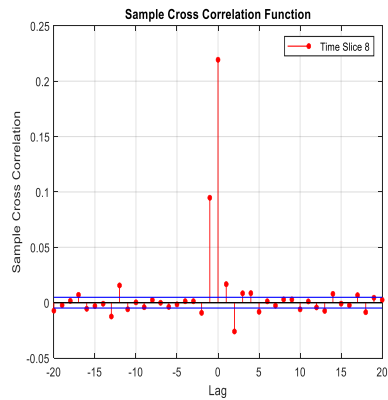
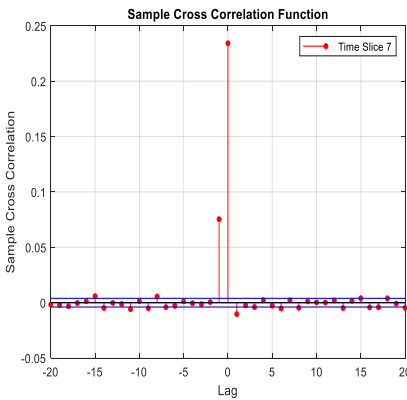
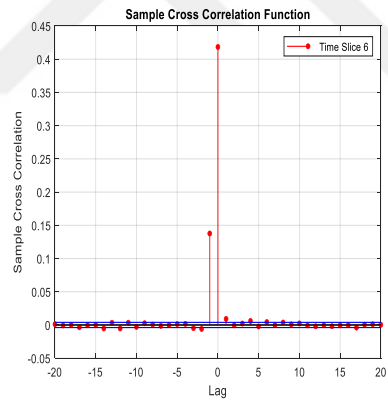
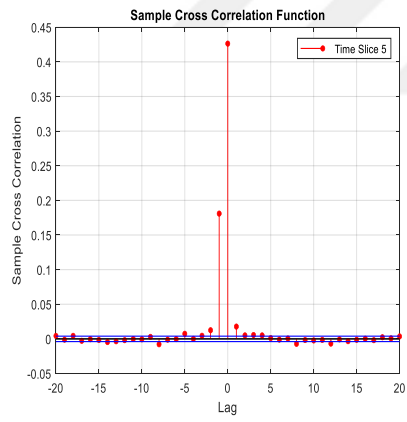
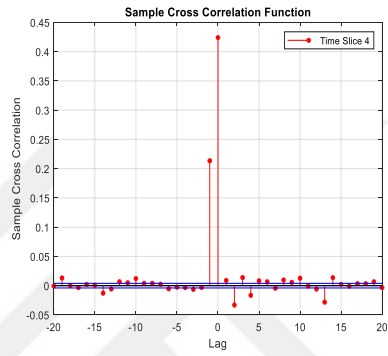
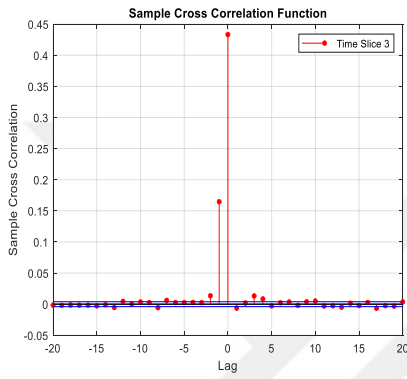
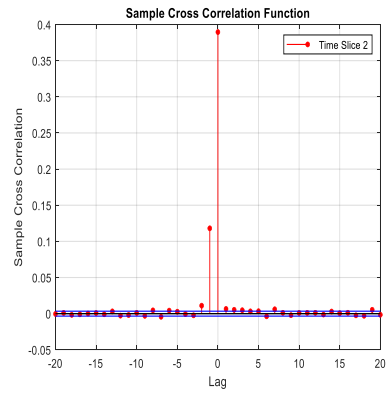
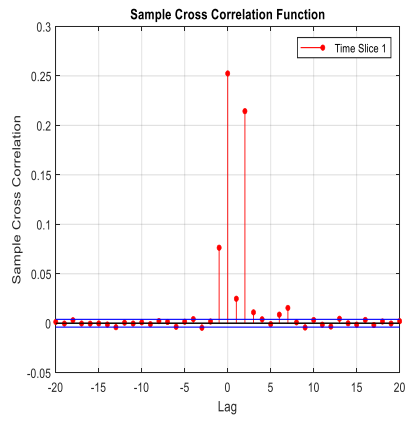
Panel A: Cross-Correlation Graphs of AUD/USD



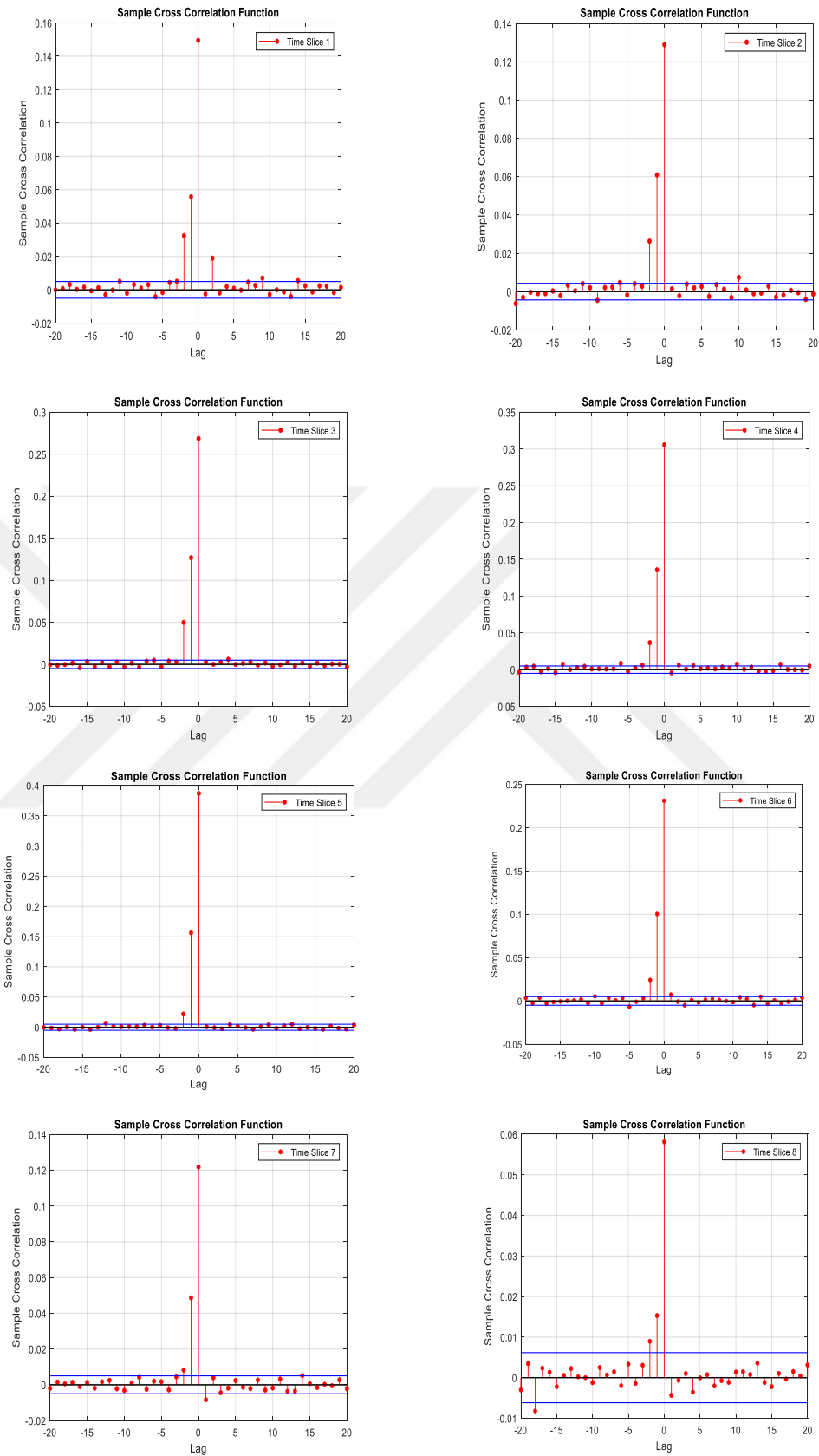
Panel B: Cross-Correlation Graphs of USD/CAD



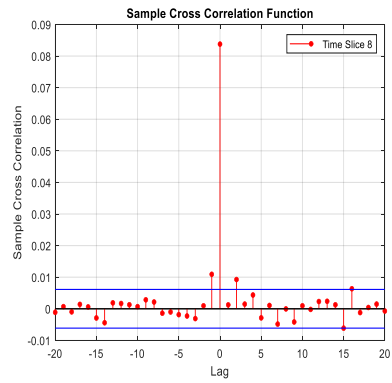
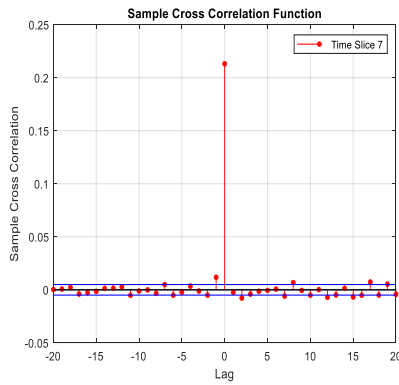
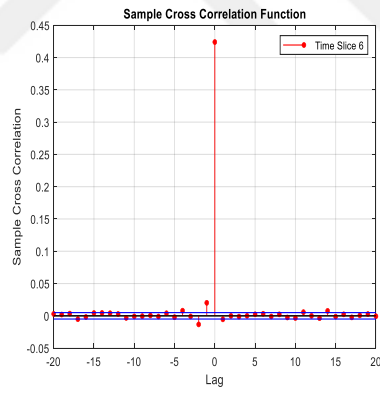
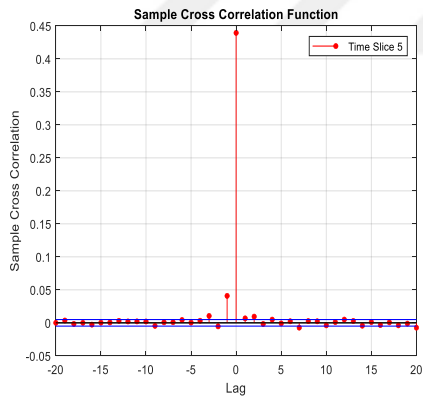
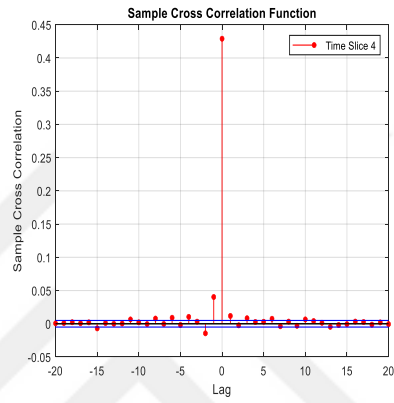
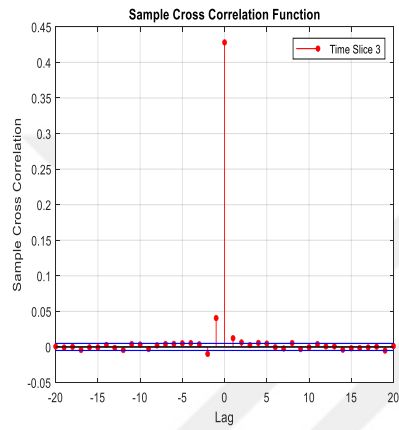
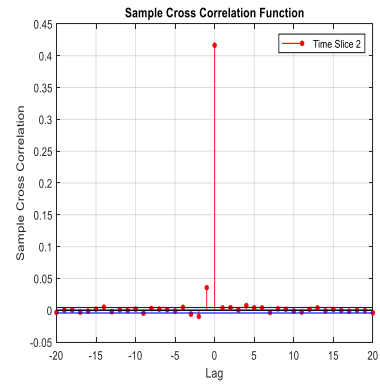
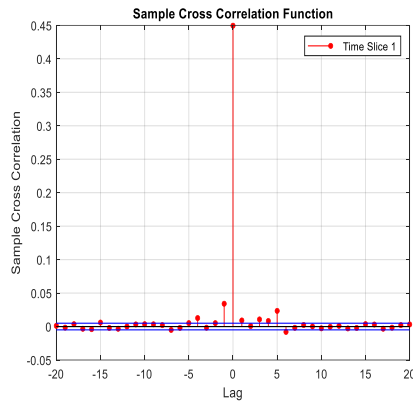
Panel C: Cross-Correlation Graphs of GBP/USD



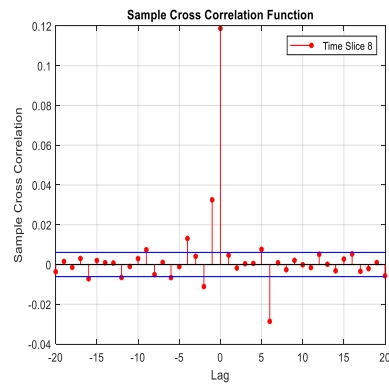
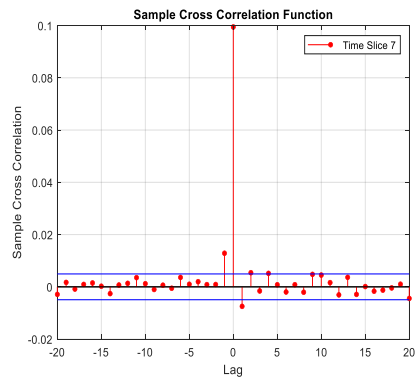
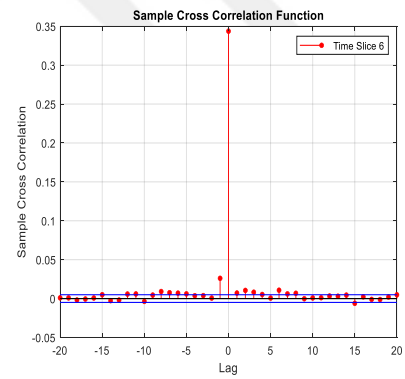
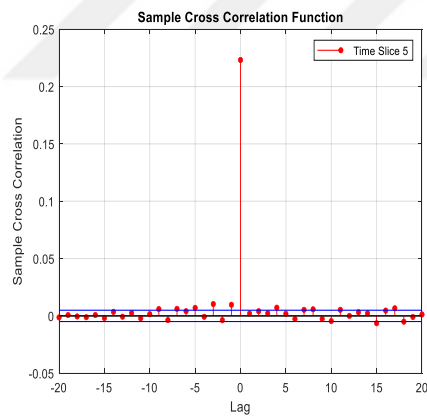
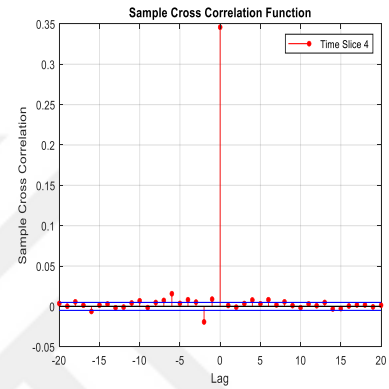
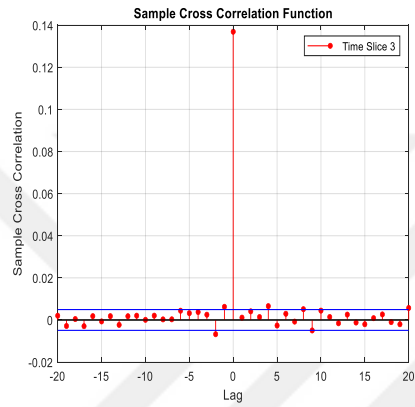
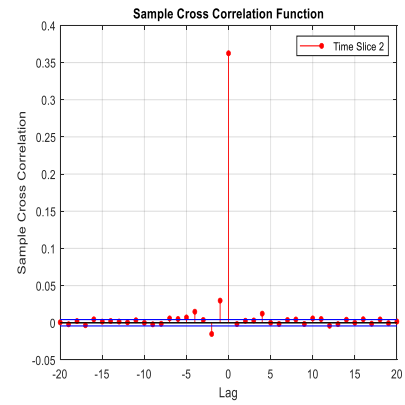
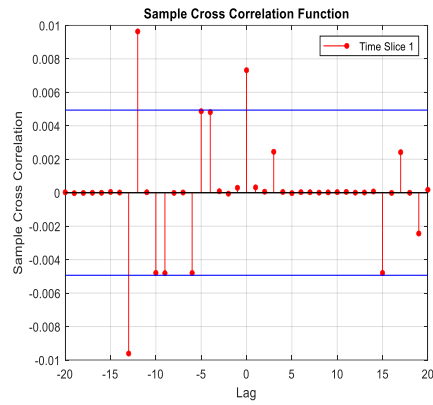
Panel D: Cross-Correlation Graphs of USD/MXN



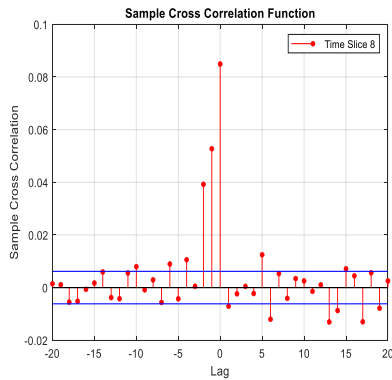
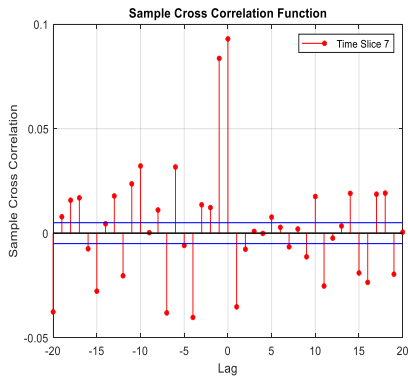
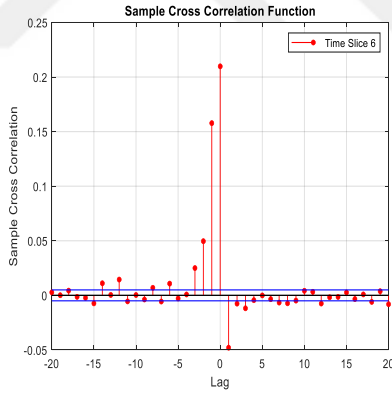
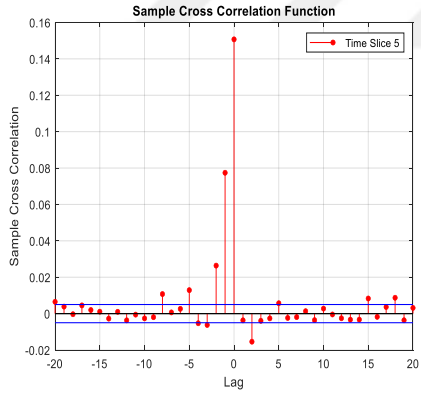
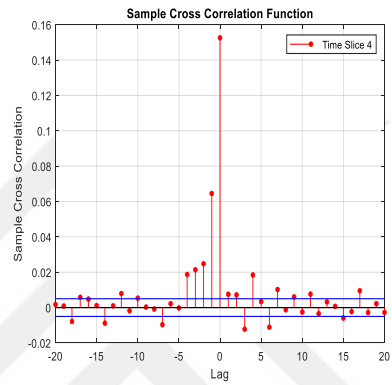
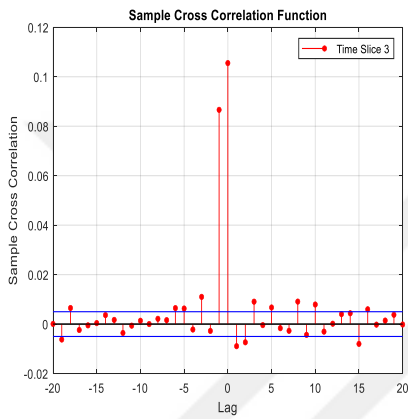
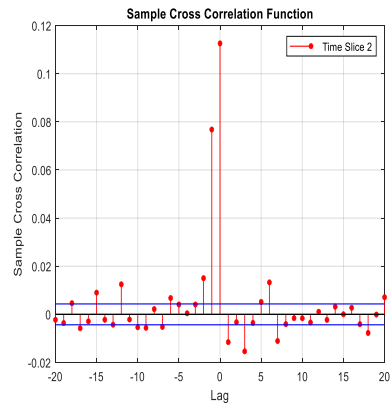
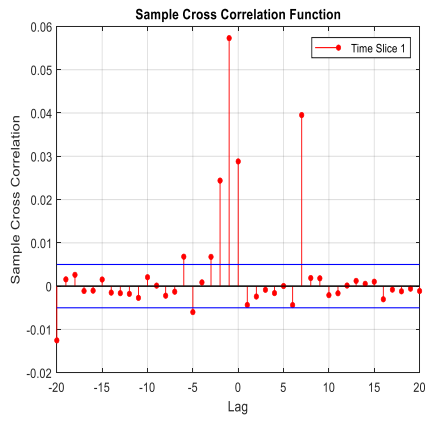
Panel E: Cross-Correlation Graphs of NZD/USD



Panel F: Cross-Correlation Graphs of USD/SGD



Panel G: Cross-Correlation Graphs of USD/TRY



Panel H: Cross-Correlation Graphs of USD/ZAR

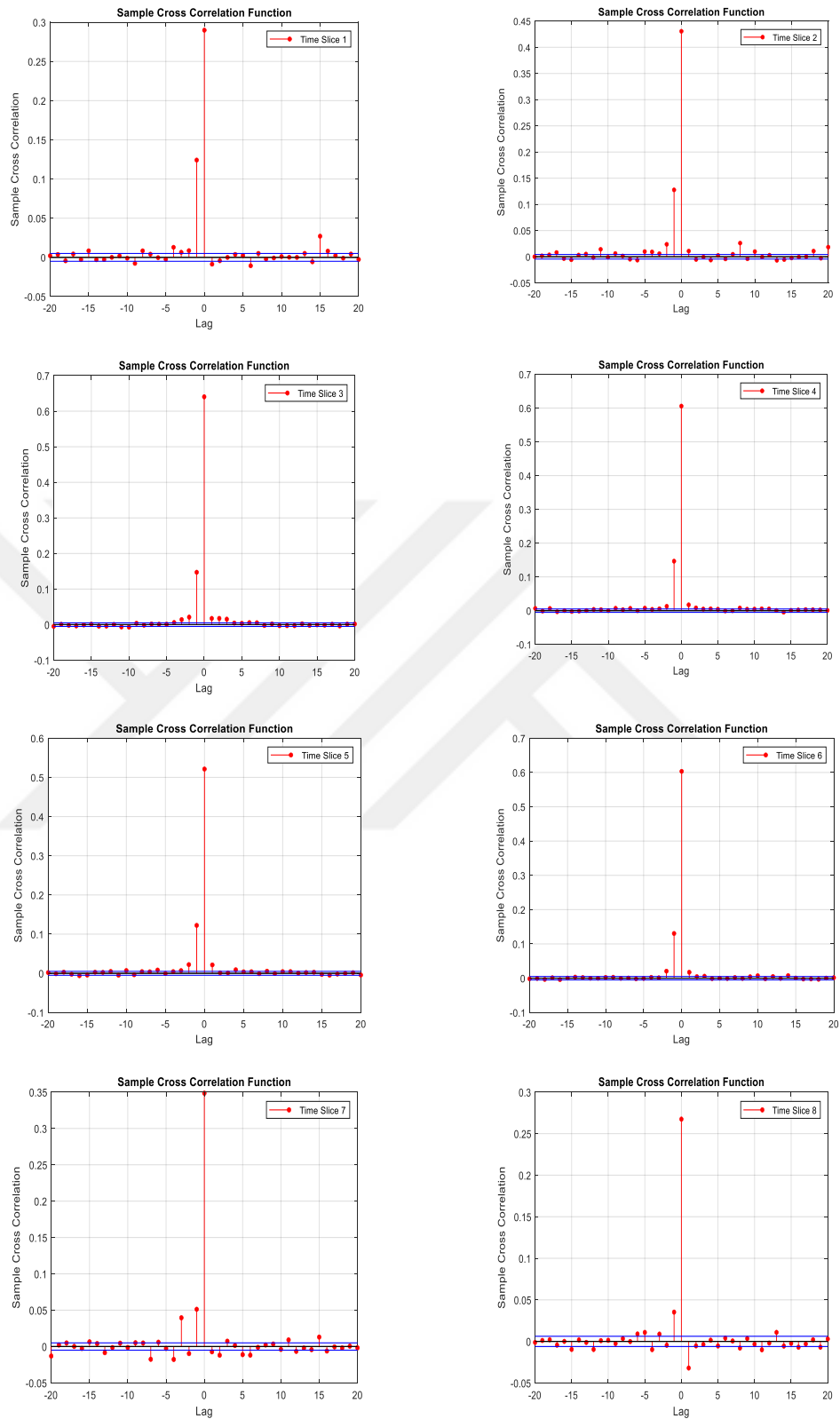


Figure 5.2 Cross-Correlations Cross-correlation graphs show the correlations between the returns calculated based on the indicative mid quotes with the leads and lags of the returns calculated based on the tradeable mid quotes.

Table 5.2
Price Discovery Shares of Indicative Quotations

This table presents the estimates of component, information and information leadership shares of indicative quotations. The values given in the table are the averages of the estimated shares for each currency and time slice from 1 to 7. Panel A shows the results for component shares, Panel B shows the results for information shares, and, Panel C shows the results for information leadership shares.

Panel A: Component Shares of Indicative Quotations								
	1	2	3	4	5	6	7	Average
AUD	0.07	0.06	0.04	0.05	0.05	0.05	0.07	0.05
CAD	0.04	0.04	0.02	0.01	0.01	0.01	0.01	0.02
GBP	0.21	0.15	0.11	0.11	0.10	0.14	0.16	0.14
MXN	0.18	0.19	0.13	0.14	0.10	0.10	0.10	0.14
NZD	0.16	0.12	0.10	0.10	0.10	0.09	0.12	0.11
SGD	0.20	0.15	0.12	0.12	0.13	0.13	0.18	0.15
TRY	0.33	0.25	0.21	0.18	0.21	0.38	0.37	0.27
ZAR	0.28	0.21	0.38	0.44	0.31	0.37	0.31	0.33

Panel B: Information Shares of Indicative Quotations								
	1	2	3	4	5	6	7	Average
AUD	0.07	0.06	0.05	0.05	0.05	0.05	0.06	0.06
CAD	0.04	0.04	0.02	0.01	0.01	0.01	0.01	0.02
GBP	0.21	0.16	0.10	0.11	0.09	0.14	0.17	0.14
MXN	0.11	0.13	0.08	0.10	0.06	0.06	0.06	0.09
NZD	0.14	0.11	0.09	0.09	0.08	0.08	0.10	0.10
SGD	0.20	0.15	0.12	0.11	0.11	0.13	0.17	0.14
TRY	0.34	0.24	0.22	0.18	0.20	0.36	0.38	0.26
ZAR	0.31	0.24	0.37	0.43	0.29	0.36	0.31	0.33

Panel C: Information Leadership Shares of Indicative Quotations								
ILS	1	2	3	4	5	6	7	Average
AUD	0.42	0.41	0.41	0.41	0.41	0.40	0.39	0.41
CAD	0.41	0.40	0.42	0.41	0.41	0.41	0.39	0.41
GBP	0.46	0.47	0.41	0.40	0.39	0.42	0.46	0.43
MXN	0.26	0.31	0.28	0.29	0.25	0.24	0.22	0.26
NZD	0.40	0.41	0.39	0.39	0.37	0.37	0.38	0.39
SGD	0.45	0.44	0.43	0.41	0.39	0.42	0.42	0.42
TRY	0.46	0.39	0.50	0.45	0.45	0.42	0.47	0.45
ZAR	0.54	0.52	0.45	0.46	0.42	0.46	0.47	0.48

However, the information leadership measure is considered, the price discovery share of the indicative quotations reaches almost 50%, suggesting that almost 50% of new information is impounded into indicative quotations, although the indicative quotes may have more noise than tradeable quotations.

The significant differences between the estimated price discovery measures support the argument of Putnins (2013) arguing that if the noise in the price series differs, the information and component shares measure a combination of leadership in

impounding new information and relative avoidance of noise to varying degrees.

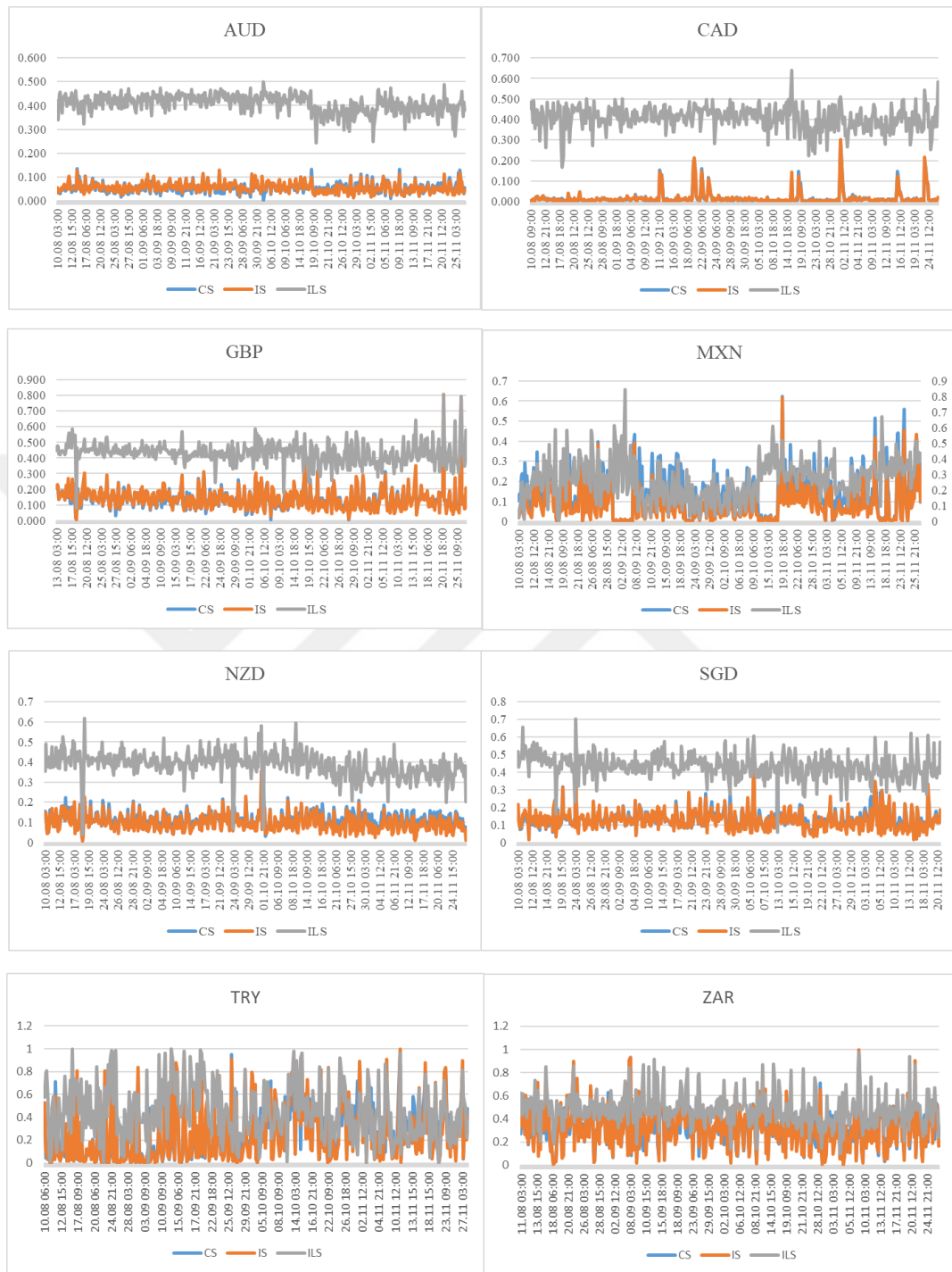


Figure 5.3 Price Discovery Shares of Indicative Quotations Graphs show the estimated component (CS), information (IS), and, information leadership (ILS) shares of indicative quotations for each of the currency pairs during the sample period.

The results also show that there are differences in the price discovery share of

indicative quotes in terms of time slices. These differences are more visible especially when the component and information share measures are considered. For most of the currencies, a U-shaped pattern is observable, where the price discovery share of the indicative quotes is highest during the time slices 1, 2, and, 7, which correspond to off-trading hours for most of the currencies, and lowest during the time slices 3, 5, and, 6, which correspond to on-trading hours.

5.3 Determinants of Price Discovery

In this part, the determinants of relative price discovery between indicative and tradeable prices are examined. First, based on the existing literature, various measures that address market characteristics are identified. Literature on equity markets concerning cross-listed stocks shows that the price discovery share of a market is positively related to the share of trading in that market and it is inversely related to the ratio of bid-ask spreads (Eun and Sabherwal, 2003; Frijns et al., 2010; Frijns et al., 2015). Liquidity, proxied by bid-ask spreads, is also expected to have an effect on the price discovery in FX markets since it represents a transaction cost for the dealers and customers. Similarly, trading activity is also expected to be one of the determinants of the relative price discovery between indicative and tradeable price series. Unfortunately, data on trades or volumes for the indicative prices are not available since the dealers only quote their bid and ask prices on the EFX page. On the other hand, for the tradeable data, it is possible to calculate the number of trades.

The seasonality patterns observed earlier show that the number of tradeable quotations is closely related to the number of trades. Moreover, the number of indicative quotations also show intraday seasonal patterns similar to the number of trades and number of tradeable quotations. Following these patterns, the number of trades, number of tradeable quotations, and, the number of indicative quotations are used to depict market activity in a currency pair.

BIS Markets Committee Report (2018) argues that during periods of market stress FX trading activity clusters in the primary ECNs as these platforms provide the highest concentration of liquidity and pre-trade anonymity. Thus, primary ECNs have an

important role in price discovery during periods of increased FX market volatility. Following this argument, price volatility is also included in the analysis.

As mentioned in Chapter 3, the FX market is open 24 hours a day and operates in various time zones and locations around the world. Due to varied activity levels and different market players, the trading volume, liquidity and market behavior changes in the different time zones and locations. Literature suggests intraday seasonality patterns and time zones have impact on the price discovery process. D'Souza (2007) shows that trades are more informative when initiated in a major foreign exchange center like London and New York. Wang and Yang (2011) find that price discovery in the FX markets are dominated by European and US trading hours. Gençay and Gradojevic (2013) demonstrate that morning and late afternoon GMT rounds of trading involve the highest risk of informed trading. In light of these findings, time zones and time slices are also included in the analysis.

For the liquidity variable, the average of bid-ask spreads of indicative and tradeable prices are calculated where the averages are based on the number of indicative and firm quotations for each of the time slices. For volatility, the square root of the sum of 1-minute mid returns of the related time slice is calculated. In addition, several ratios are calculated to account for the relative trading activity, liquidity, and, volatility in the tradeable and indicative prices. The trade ratio variable is calculated as the number of trades divided by the number of tradeable quotations. The spread ratio variable is equal to the average bid-ask indicative spread divided by the average bid-ask tradeable spread. Similarly, the number of quotations ratio variable is the number of indicative quotations divided by the number of tradeable quotations, and, finally, the volatility ratio equals to the ratio of volatility of the indicative price series to the volatility of the tradeable price series.

Several dummy variables are added to the model in order to identify the effects of different time zones. The dummy Asian trading session is equal to 1 when only the Asian markets are in session, and 0 otherwise. The dummy Asian and London trading session is equal to 1 when the Asian and London markets are both in session, and 0 otherwise. The dummy London trading session is equal to 1 when only the London

markets are in session but Asian and US markets are closed), and 0 otherwise. The dummy London and US trading session is equal to 1 when both London and US markets are in session but the Asian market is closed, and 0 otherwise. Finally, the dummy US trading session is equal to 1 when only the US markets are in session, and 0 otherwise.

Table 5.3 presents the definition of all explanatory variables used, Table 5.4 shows the summary statistics of the explanatory variables and Table 5.5 presents the correlation values between the variables.

Table 5.3
Definitions of Explanatory Variables

This table provides the definitions of the variables included in the analyses.

Variable Name	Definition
Indicative spread	Average of bid-ask spreads for indicative prices calculated for each time slice and multiplied by 10,000
Tradeable spread	Average of bid-ask spreads for the tradeable prices, calculated for each time slice and multiplied by 10,000
Spread ratio	Average bid-ask indicative spread divided by the average bid-ask tradeable spread
N of Indicative Quotations	Number of indicative quotations divided by 10,000 in the related time slice
N of Tradeable Quotations	Number of tradeable quotations divided by 10,000 in the related time slice
Ratio of number of quotations	Number of indicative quotations divided by the number of tradeable quotations in a time slice
Trade ratio	Number of trades divided by the number of tradeable quotations for each time slice
Indicative Volatility	Square root of the sum of 1-minute mid indicative returns of the related time slice
Tradeable Volatility	Square root of the sum of 1-minute mid tradeable returns of the related time slice
Volatility ratio	Ratio of the volatility of indicative prices to the volatility of tradeable prices
Asian trading session	Equal to 1 when only the Asian markets are in session, and 0 otherwise
Asian and London trading session	Equal to 1 when the Asian and London markets are both in session, and 0 otherwise
London trading session	Equal to 1 when only the London markets are in session but Asian and US markets are closed, and 0 otherwise.
London and US trading session	Equal to 1 when both London and US markets are in session but the Asian market is closed, and 0 otherwise.
US trading session	Equal to 1 when only the US markets are in session, and 0 otherwise.
London off	Equal to 1 when the London market is closed, and 0 otherwise.
Local off	Equal to 1 when the local market for the currency is closed, and 0 otherwise.
Active off	Equal to 1 when the local market or London market for the currency is closed, and 0 otherwise. For GBP/USD only, this variable is equal to 1 when either London or US market is off, and 0 otherwise.

Similarly, the dummy *Local off* is equal to 1 when the local market for the currency is closed, and 0 otherwise. *Active off* is equal to 1 when the local market or London market for the currency is closed, and 0 otherwise.

Table 5.4
Descriptive Statistics of Explanatory Variables

This table shows the descriptive statistics of explanatory variables calculated for different currencies. *Indicative spread* is the average of bid-ask spreads for indicative prices, calculated for each time slice and multiplied by 10,000. *Tradeable spread* is the average of bid-ask spreads for the tradeable prices, calculated for each time slice and multiplied by 10,000. *Spread ratio* is the average bid-ask indicative spread divided by the average bid-ask tradeable spread. *N of Indicative Quotations* is the number of indicative quotations divided by 10,000 in the related time slice, while *N of Tradeable Quotations* is the number of tradeable quotations divided by 10,000 in the related time slice. *Ratio of number of quotations* is the number of indicative quotations divided by the number of tradeable quotations in a time slice. *Trade ratio* is the number of trades divided by the number of tradeable quotations for each time slice. *Volatility* is the square root of the sum of 1-minute mid returns of the related time slice while *volatility ratio* is the ratio of the volatility of indicative prices to the volatility of tradeable prices.

	Mean	Median	St. Dev	Skewness	Kurtosis
Panel A: AUD/USD					
Indicative Spread	2.03	1.96	0.35	0.03	-1.16
Tradeable Spread	1.21	1.19	0.12	2.34	9.90
Spread Ratio	1.70	1.67	0.35	0.05	-0.93
N of Indicative Quotations	10.48	10.29	2.69	1.03	2.90
N of Tradeable Quotations	3.53	3.13	1.89	1.83	5.90
Ratio of Number of Quotations	3.43	3.21	1.11	0.77	0.43
Trade Ratio	0.18	0.17	0.06	0.48	0.09
Volatility of Indicative Series	0.24	0.21	0.19	8.66	96.54
Volatility Ratio	1.00	1.00	0.01	-0.23	4.13
Panel B: USD/CAD					
Indicative Spread	3.08	3.09	0.52	-0.42	-0.63
Tradeable Spread	2.27	2.29	0.20	0.82	8.53
Spread Ratio	1.37	1.40	0.25	-0.42	-0.43
N of Indicative Quotations	12.56	12.27	3.44	0.31	0.41
N of Tradeable Quotations	1.96	1.72	1.11	1.61	3.80
Ratio of Number of Quotations	7.66	7.16	3.43	4.68	46.85
Trade Ratio	0.15	0.14	0.07	0.51	0.10
Volatility of Indicative Series	0.23	0.22	0.06	1.09	5.41
Volatility Ratio	1.44	1.42	0.28	0.93	3.66
Panel C: GBP/USD					
Indicative Spread	2.80	2.78	0.59	-0.03	-1.32
Tradeable Spread	2.54	2.46	0.36	2.32	8.56
Spread Ratio	1.12	1.12	0.27	0.00	-0.83
N of Indicative Quotations	18.96	19.13	4.29	-0.08	-0.29
N of Tradeable Quotations	2.63	2.40	1.69	1.10	1.64
Ratio of Number of Quotations	10.32	8.40	6.47	1.62	3.29
Trade Ratio	0.12	0.12	0.06	0.55	0.44
Volatility of Indicative Series	0.22	0.21	0.10	1.54	6.12
Volatility Ratio	1.00	1.01	0.09	-4.83	35.42

Table 5.4 (cont'd)

	Mean	Median	St. Dev	Skewness	Kurtosis
Panel D: USD/MXN					
Indicative Spread	148.18	146.53	76.55	1.37	3.55
Tradeable Spread	120.65	114.56	42.29	1.32	4.49
Spread Ratio	1.20	1.12	0.37	0.82	1.13
N of Indicative Quotations	11.74	8.60	7.92	1.00	0.13
N of Tradeable Quotations	2.21	1.82	1.61	1.18	1.36
Ratio of Number of Quotations	7.55	5.38	6.80	3.12	14.91
Trade Ratio	0.08	0.07	0.06	1.08	1.70
Volatility of Indicative Series	0.39	0.34	0.21	1.77	7.04
Volatility Ratio	1.22	1.01	0.72	4.53	26.36
Panel E: NZD/USD					
Indicative Spread	3.33	3.35	0.19	-0.52	0.61
Tradeable Spread	1.92	1.87	0.35	5.59	66.97
Spread Ratio	1.77	1.77	0.24	-0.62	1.55
N of Indicative Quotations	5.32	5.15	2.28	0.75	0.83
N of Tradeable Quotations	1.24	1.07	0.82	2.54	11.08
Ratio of Number of Quotations	4.82	4.70	1.34	1.92	14.82
Trade Ratio	0.15	0.15	0.07	0.84	1.41
Volatility of Indicative Series	0.25	0.23	0.09	3.32	21.65
Volatility Ratio	1.07	1.06	0.12	-0.22	22.82
Panel F: USD/SGD					
Indicative Spread	4.14	4.15	0.39	-0.06	-0.21
Tradeable Spread	5.08	2.48	12.91	7.05	66.43
Spread Ratio	1.60	1.64	0.47	-1.33	2.75
N of Indicative Quotations	2.37	2.29	0.96	0.48	-0.15
N of Tradeable Quotations	0.96	0.84	0.58	2.01	7.48
Ratio of Number of Quotations	2.86	2.75	1.01	0.87	2.75
Trade Ratio	0.21	0.19	0.14	0.80	0.37
Volatility of Indicative Series	0.11	0.10	0.04	3.05	18.55
Volatility Ratio	1.07	1.08	0.24	-0.48	13.63
Panel G: USD/TRY					
Indicative Spread	60.58	62.73	16.51	-0.38	-0.95
Tradeable Spread	130.19	99.60	99.72	2.11	5.41
Spread Ratio	0.63	0.59	0.32	3.04	23.02
N of Indicative Quotations	20.48	21.17	4.67	-0.61	0.29
N of Tradeable Quotations	0.29	0.22	0.27	1.73	4.09
Ratio of Number of Quotations	276.95	90.88	543.05	4.48	26.12
Trade Ratio	0.28	0.27	0.13	0.69	2.07
Volatility of Indicative Series	0.46	0.35	0.40	4.05	30.82
Volatility Ratio	1.31	1.00	0.93	3.55	17.62

Table 5.4 (cont'd)

Panel H: USD/ZAR					
Indicative Spread	107.04	94.50	38.31	1.31	1.39
Tradeable Spread	187.58	152.90	91.45	1.61	3.20
Spread Ratio	0.61	0.61	0.11	-0.14	0.28
N of Indicative Quotations	25.16	25.10	5.95	-0.49	-0.04
N of Tradeable Quotations	0.93	0.80	0.71	1.69	5.15
Ratio of Number of Quotations	51.81	32.24	58.49	3.62	17.11
Trade Ratio	0.11	0.11	0.07	0.31	-0.32
Volatility of Indicative Series	0.37	0.35	0.17	1.17	2.74
Volatility Ratio	1.00	1.00	0.13	1.46	15.76

For GBP/USD only, this variable is equal to 1 when either London or US market is off, and 0 otherwise.

The following model is estimated for each currency pair and price discovery measure separately:

$$PDM_t = \alpha + \beta MV_t + \gamma TS_t + \delta D_t + \varepsilon_t \quad (5.1)$$

In Equation 5.1, *PDM* corresponds to the related price discovery measure, i.e. component share, information share, and information leadership share. *MV* is the vector of explanatory variables, *TS* is the vector of trading session dummy variables, and, *D* is the vector of days of the week dummies. The models are estimated within the OLS framework and robust (Newey West) standard errors are used in order to account for possible heteroskedasticity and autocorrelation effects.

In Model 1, the dependent variable is one of the price discovery measures calculated for the indicative prices and explanatory variables are the ones that are related to the indicative quotes and trading sessions. In Model 2, the dependent variable is one of the price discovery measures of the tradeable quotes and the explanatory variables are variables related to the series of the tradeable quotes and trading sessions. For the Models 3-6, the dependent variable is one of the price discovery measures calculated for the indicative prices. Model 3 includes the variables based on ratios and trading sessions. In the first three models, estimations are carried out for when only the London market is in session.

Table 5.5
Correlation Matrix of Explanatory Variables

This table presents the Pearson correlation coefficients between the explanatory variables. Correlation values greater than 0.7 or smaller than -0.7 are given in bold.

	Ind. Spread	Spread Ratio	Trd. Spread	No of Ind. Quot.	Ratio of No of Quot.	No of Trd. Quot.	Trade Ratio	Vol. Ratio	Ind. Vol.	Trd. Vol.
Panel A: GBP/USD										
Indicative Spread	1.00	0.87	0.00	0.49	-0.72	0.78	0.52	0.11	0.73	0.60
Spread Ratio	0.87	1.00	-0.47	0.33	-0.68	0.63	0.57	0.13	0.53	0.42
Tradeable Spread	0.00	-0.47	1.00	0.18	0.12	0.10	-0.20	-0.07	0.19	0.18
N of Indicative Quotations	0.49	0.33	0.18	1.00	-0.37	0.60	0.45	0.08	0.53	0.43
Ratio of Number of Quotations	-0.72	-0.68	0.12	-0.37	1.00	-0.75	-0.35	0.05	-0.67	-0.60
N of Tradeable Quotations	0.78	0.63	0.10	0.60	-0.75	1.00	0.44	0.01	0.85	0.75
Trade Ratio	0.52	0.57	-0.20	0.45	-0.35	0.44	1.00	0.07	0.41	0.34
Volatility Ratio	0.11	0.13	-0.07	0.08	0.05	0.01	0.07	1.00	-0.04	-0.39
Indicative Volatility	0.73	0.53	0.19	0.53	-0.67	0.85	0.41	-0.04	1.00	0.91
Tradeable Volatility	0.60	0.42	0.18	0.43	-0.60	0.75	0.34	-0.39	0.91	1.00
Panel B: USD/MXN										
Indicative Spread	1.00	0.73	0.81	0.07	0.21	-0.12	-0.48	0.31	0.02	0.36
Spread Ratio	0.73	1.00	0.25	0.39	0.24	0.12	-0.20	0.15	-0.03	0.19
Tradeable Spread	0.81	0.25	1.00	-0.25	0.17	-0.34	-0.61	0.27	0.07	0.30
N of Indicative Quotations	0.07	0.39	-0.25	1.00	0.26	0.45	0.25	0.36	0.14	0.19
Ratio of Number of Quotations	0.21	0.24	0.17	0.26	1.00	-0.45	-0.27	0.07	0.63	-0.21
N of Tradeable Quotations	-0.12	0.12	-0.34	0.45	-0.45	1.00	0.49	0.44	-0.16	0.53
Trade Ratio	-0.48	-0.20	-0.61	0.25	-0.27	0.49	1.00	0.14	-0.07	0.15
Volatility Ratio	0.31	0.15	0.27	0.36	0.07	0.44	0.14	1.00	0.31	0.84
Indicative Volatility	0.02	-0.03	0.07	0.14	0.63	-0.16	-0.07	0.31	1.00	-0.09
Tradeable Volatility	0.36	0.19	0.30	0.19	-0.21	0.53	0.15	0.84	-0.09	1.00
Panel C: AUD/USD										
Indicative Spread	1.00	0.90	-0.14	0.22	-0.58	0.43	0.16	0.12	-0.03	0.12
Spread Ratio	0.90	1.00	-0.54	-0.01	-0.46	0.21	0.30	-0.02	-0.05	-0.02
Tradeable Spread	-0.14	-0.54	1.00	0.47	-0.08	0.38	-0.35	0.30	0.05	0.30
N of Indicative Quotations	0.22	-0.01	0.47	1.00	-0.50	0.82	-0.02	0.41	0.08	0.41
Ratio of Number of Quotations	-0.58	-0.46	-0.08	-0.50	1.00	-0.78	0.01	-0.26	-0.01	-0.26
N of Tradeable Quotations	0.43	0.21	0.38	0.82	-0.78	1.00	-0.03	0.40	0.05	0.40
Trade Ratio	0.16	0.30	-0.35	-0.02	0.01	-0.03	1.00	0.09	0.08	0.09
Volatility Ratio	0.12	-0.02	0.30	0.41	-0.26	0.40	0.09	1.00	0.04	1.00
Indicative Volatility	-0.03	-0.05	0.05	0.08	-0.01	0.05	0.08	0.04	1.00	0.03
Tradeable Volatility	0.12	-0.02	0.30	0.41	-0.26	0.40	0.09	1.00	0.03	1.00

Table 5.5 (cont'd)

	Ind. Spread	Spread Ratio	Trd. Spread	No of Ind. Quot.	Ratio of No of Quot.	No of Trd. Quot.	Trade Ratio	Vol. Ratio	Ind. Vol.	Trd. Vol.
Panel D: USD/CAD										
Indicative Spread	1.00	0.89	0.02	0.31	-0.58	0.54	0.18	0.54	-0.16	0.45
Spread Ratio	0.89	1.00	-0.43	0.25	-0.55	0.42	0.37	0.44	-0.06	0.32
Tradeable Spread	0.02	-0.43	1.00	0.05	0.16	0.12	-0.41	0.11	-0.15	0.17
N of Indicative Quotations	0.31	0.25	0.05	1.00	-0.38	0.78	0.27	0.71	-0.30	0.66
Ratio of Number of Quotations	-0.58	-0.55	0.16	-0.38	1.00	-0.64	-0.14	-0.50	0.52	-0.56
N of Tradeable Quotations	0.54	0.42	0.12	0.78	-0.64	1.00	0.26	0.84	-0.47	0.88
Trade Ratio	0.18	0.37	-0.41	0.27	-0.14	0.26	1.00	0.28	-0.07	0.22
Volatility Ratio	0.54	0.44	0.11	0.71	-0.50	0.84	0.28	1.00	-0.22	0.89
Indicative Volatility	-0.16	-0.06	-0.15	-0.30	0.52	-0.47	-0.07	-0.22	1.00	-0.60
Tradeable Volatility	0.45	0.32	0.17	0.66	-0.56	0.88	0.22	0.89	-0.60	1.00
Panel E: NZD/USD										
Indicative Spread	1.00	0.25	0.12	0.73	-0.22	0.58	-0.13	0.51	-0.37	0.39
Spread Ratio	0.25	1.00	-0.84	0.22	0.02	0.04	0.29	-0.01	-0.12	0.01
Tradeable Spread	0.12	-0.84	1.00	0.02	0.08	0.12	-0.31	0.15	0.00	0.10
N of Indicative Quotations	0.73	0.22	0.02	1.00	-0.34	0.86	-0.15	0.66	-0.36	0.48
Ratio of Number of Quotations	-0.22	0.02	0.08	-0.34	1.00	-0.60	0.00	-0.48	0.29	-0.38
N of Tradeable Quotations	0.58	0.04	0.12	0.86	-0.60	1.00	-0.13	0.77	-0.34	0.56
Trade Ratio	-0.13	0.29	-0.31	-0.15	0.00	-0.13	1.00	-0.01	0.04	-0.01
Volatility Ratio	0.51	-0.01	0.15	0.66	-0.48	0.77	-0.01	1.00	-0.26	0.73
Indicative Volatility	-0.37	-0.12	0.00	-0.36	0.29	-0.34	0.04	-0.26	1.00	-0.63
Tradeable Volatility	0.39	0.01	0.10	0.48	-0.38	0.56	-0.01	0.73	-0.63	1.00
Panel F: USD/SGD										
Indicative Spread	1.00	0.20	-0.09	0.17	0.20	-0.17	0.06	-0.05	0.46	-0.01
Spread Ratio	0.20	1.00	-0.65	-0.30	0.06	0.11	0.50	0.51	-0.10	-0.15
Tradeable Spread	-0.09	-0.65	1.00	0.53	-0.13	-0.40	-0.31	-0.61	-0.04	0.57
N of Indicative Quotations	0.17	-0.30	0.53	1.00	0.59	-0.64	-0.22	-0.48	0.48	0.31
Ratio of Number of Quotations	0.20	0.06	-0.13	0.59	1.00	-0.08	-0.05	-0.06	0.62	-0.03
N of Tradeable Quotations	-0.17	0.11	-0.40	-0.64	-0.08	1.00	0.10	0.42	-0.21	-0.11
Trade Ratio	0.06	0.50	-0.31	-0.22	-0.05	0.10	1.00	0.27	-0.04	-0.07
Volatility Ratio	-0.05	0.51	-0.61	-0.48	-0.06	0.42	0.27	1.00	-0.04	-0.20
Indicative Volatility	0.46	-0.10	-0.04	0.48	0.62	-0.21	-0.04	-0.04	1.00	-0.03
Tradeable Volatility	-0.01	-0.15	0.57	0.31	-0.03	-0.11	-0.07	-0.20	-0.03	1.00

Table 5.5 (cont'd)

	Ind. Spread	Spread Ratio	Trd. Spread	No of Ind. Quot.	Ratio of No of Quot.	No of Trd. Quot.	Trade Ratio	Vol. Ratio	Ind. Vol.	Trd. Vol.
Panel G: USD/ZAR										
Indicative Spread	1.00	-0.28	0.87	-0.58	0.24	-0.24	-0.52	-0.16	-0.02	-0.12
Spread Ratio	-0.28	1.00	-0.65	0.40	-0.11	0.08	0.41	0.13	0.13	0.08
Tradeable Spread	0.87	-0.65	1.00	-0.62	0.22	-0.13	-0.57	-0.16	-0.08	-0.11
N of Indicative Quotations	-0.58	0.40	-0.62	1.00	-0.34	0.50	0.46	0.40	-0.04	0.36
Ratio of Number of Quotations	0.24	-0.11	0.22	-0.34	1.00	-0.55	-0.12	-0.49	0.22	-0.48
N of Tradeable Quotations	-0.24	0.08	-0.13	0.50	-0.55	1.00	0.17	0.56	-0.05	0.52
Trade Ratio	-0.52	0.41	-0.57	0.46	-0.12	0.17	1.00	0.46	-0.02	0.44
Volatility Ratio	-0.16	0.13	-0.16	0.40	-0.49	0.56	0.46	1.00	-0.07	0.96
Indicative Volatility	-0.02	0.13	-0.08	-0.04	0.22	-0.05	-0.02	-0.07	1.00	-0.29
Tradeable Volatility	-0.12	0.08	-0.11	0.36	-0.48	0.52	0.44	0.96	-0.29	1.00
Panel H: USD/TRY										
Indicative Spread	1.00	-0.26	0.51	-0.48	0.22	-0.03	-0.27	0.25	-0.18	0.34
Spread Ratio	-0.26	1.00	-0.66	0.14	-0.09	-0.04	0.54	-0.17	0.30	-0.35
Tradeable Spread	0.51	-0.66	1.00	-0.48	0.25	-0.12	-0.51	0.12	-0.25	0.36
N of Indicative Quotations	-0.48	0.14	-0.48	1.00	-0.30	0.49	0.25	0.11	0.07	0.00
Ratio of Number of Quotations	0.22	-0.09	0.25	-0.30	1.00	-0.40	-0.28	-0.26	0.11	-0.24
N of Tradeable Quotations	-0.03	-0.04	-0.12	0.49	-0.40	1.00	0.26	0.55	-0.06	0.50
Trade Ratio	-0.27	0.54	-0.51	0.25	-0.28	0.26	1.00	0.04	0.18	-0.06
Volatility Ratio	0.25	-0.17	0.12	0.11	-0.26	0.55	0.04	1.00	0.15	0.83
Indicative Volatility	-0.18	0.30	-0.25	0.07	0.11	-0.06	0.18	0.15	1.00	-0.25
Tradeable Volatility	0.34	-0.35	0.36	0.00	-0.24	0.50	-0.06	0.83	-0.25	1.00

In the Models 4, 5, and, 6, the trading session dummies are dropped and dummy variables representing the off-trading hours in London (Model 4), and off-trading hours in the related local market and London market (Model 5), and off-trading hours in the local market (Model 6) are added. To extend the analysis, Models 1 to 3 are re-estimated for the sample covering only on-trading hours in London and covering only on-trading hours in the related local market. The models 3-6 are not estimated separately for the models where price discovery measures for tradeable quotations because the results would be similar since the explanatory variables used are ratios of indicative versus tradeable series and price discovery measures of indicative and tradeable quotations sums to 1.

Tables 5.6-5.8 shows the coefficients from the Model-1 for all the exchange rates in a single table for all sample, for the sample where London market is open and for the sample where local market is open, accordingly. Similarly, Tables 5.9-5.11 shows the coefficients from the Model-2 for all the exchange rates in a single table, and Tables 5.12-5.14 shows the coefficients from the Model-3 for all the exchange rates in a single table. In all of these tables bold coefficients are significant with at least 10 percent probability.

Based on the summary tables, it is observed that the selected explanatory variables are successful at explaining the variation in the price discovery measures. The adjusted R-squared values are high especially for GBP/USD, USD/MXN, USD/CAD, USD/SGD and USD/ZAR. Also, it should be noted that the adjusted R-squared values are higher when the dependent variable is the component share measure, except for GBP/USD and USD/MXN where adjusted R-squared values are highest when the dependent variable is the information leadership measure. It is also seen that adjusted R-squared values are high when the dependent variable is the information leadership measure especially for GBP/USD, USD/MXN, USD/SGD whose trade ratio in the Reuters Matching platform is the lowest.

The results show that the spread ratio, the ratio of the number of quotations and the volatility ratio are significant market variables in explaining the variation in the price discovery measures. Furthermore, volatility ratio is mostly significant in the component and information share measures. On the other hand, spread ratio and ratio of number of quotations is mostly significant for the information leadership share. As discussed in Chapter 4, simulations of Putnins (2013) illustrate that information and component share metrics measure a combination of leadership (relative speed) in impounding new information and relative avoidance of noise, to different extents, and information leadership metric only measures speed. Thus, it is not surprising that volatility, which is expected to be positively related with noise, is significant for component and information share metrics while it is not significant for the information leadership metric. Both theoretical models as well as empirical findings show that the trading flows aggregate the dispersed private information that is relevant for pricing exchange rates. On the other hand, the microstructure literature shows bid-ask spreads

are updated based on the trading activities of the informed market participants. Thus, it is expected that information leadership measure is affected from the variables related to the trading activity, namely spread ratio and ratio of number of quotations.

Table 5.6
Summary of Model 1 Results – Full Sample

This table presents the coefficients of Model-1 for all the exchange rates. Bold coefficients are significant at an alpha level of 10 percent or better. Panel A shows the results for component share. Panel B gives the results for information share. Panel C gives the results for information leadership share. Variable definitions are given in Table 5.3.

Panel A: Component Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.286	0.211	0.064	0.156	0.063	0.095	0.484	0.116
Ind Spread	-0.039	0.000	-0.009	-0.031	0.010	0.016	-0.001	0.000
N of Ind Quotations	-0.002	-0.004	0.000	-0.002	0.000	-0.007	0.002	0.004
Volatility	-0.013	-0.125	0.002	0.222	-0.022	0.461	-0.087	0.023
Only Asian TS	0.012	0.016	0.011	-0.016	0.034	0.031	-0.134	0.134
Asian & London TS	-0.011	-0.022	-0.002	0.004	0.002	0.005	-0.045	0.031
London & US TS	0.008	-0.005	0.001	-0.003	-0.008	0.012	-0.094	0.127
US TS	0.016	-0.034	0.015	-0.025	0.022	0.044	-0.116	0.218
Adj R-squared	0.25	0.313	0.160	0.241	0.196	0.053	0.205	0.070
Panel B: Information Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.343	0.157	0.039	0.147	0.043	0.001	0.536	0.180
Ind Spread	-0.047	0.000	-0.003	-0.029	0.013	0.038	-0.001	-0.002
N of Ind Quotations	-0.004	-0.001	0.001	-0.002	0.000	-0.003	0.001	0.006
Volatility	0.016	-0.086	0.002	0.214	-0.037	-0.084	-0.149	0.021
Only Asian TS	0.004	0.020	0.014	-0.015	0.032	0.027	-0.107	0.200
Asian & London TS	-0.012	-0.012	-0.003	0.004	0.001	-0.004	-0.042	0.066
London & US TS	0.011	-0.025	-0.001	-0.003	-0.010	0.004	-0.093	0.135
US TS	0.015	-0.040	0.015	-0.024	0.014	0.037	-0.117	0.287
Adj R-squared	0.270	0.200	0.152	0.216	0.168	0.086	0.122	0.060
Panel C: Information Leadership Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.587	0.308	0.330	0.393	0.423	0.183	0.553	0.640
Ind Spread	-0.029	-0.001	0.024	0.010	-0.006	0.066	0.000	-0.005
N of Ind Quotations	-0.004	0.009	0.002	0.002	-0.001	0.002	0.000	0.004
Volatility	0.025	0.042	0.004	-0.196	-0.063	-1.368	-0.197	0.012
Only Asian TS	0.008	0.076	0.012	-0.005	0.011	-0.001	0.071	0.116
Asian & London TS	-0.005	0.032	-0.007	0.005	0.006	-0.004	0.003	0.094
London & US TS	0.008	-0.124	-0.007	-0.007	-0.016	-0.011	-0.016	0.030
US TS	0.022	-0.101	-0.001	-0.016	-0.021	0.002	-0.006	0.156
Adj R-squared	0.250	0.290	0.080	0.040	0.037	0.070	0.138	0.088

Table 5.7

Summary of Model 1 Results – London Market Hours Table

This table presents the coefficients of Model-1 using only London market hours as the sample. Bold coefficients are significant at an alpha level of 10 percent or better. Panel A shows the results for component share. Panel B gives the results for information share. Panel C gives the results for information leadership share. Variable definitions are given in Table 5.3.

Panel A: Component Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.382	0.218	0.055	0.02	0.152	0.126	0.546	-0.130
Ind Spread	-0.053	0.000	-0.005	0.00	-0.021	0.010	-0.001	0.003
N of Ind Quotations	-0.005	-0.003	0.001	0.00	0.004	-0.016	0.002	0.009
Volatility	-0.055	-0.238	-0.067	-0.06	-0.192	1.036	-0.284	-0.054
Only Asian TS	-0.014	-0.023	-0.002	0.01	0.004	0.010	-0.031	0.007
Asian & London TS	0.013	0.006	0.003	0.00	-0.007	0.012	-0.091	0.104
Adj R-squared	0.217	0.355	0.050	0.071	0.120	0.005	0.246	0.071
Panel B: Information Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.460	0.168	0.035	0.015	0.073	0.007	0.645	-0.022
Ind Spread	-0.068	0.000	0.002	0.004	0.001	0.039	-0.001	0.001
N of Ind Quotations	-0.007	-0.001	0.001	0.000	0.004	-0.011	-0.002	0.009
Volatility	0.037	-0.169	-0.061	-0.082	-0.228	0.050	-0.328	-0.062
Asian & London TS	-0.015	-0.013	-0.003	0.007	0.000	0.000	-0.036	0.040
London & US TS	0.016	-0.016	0.002	0.003	-0.009	0.005	-0.098	0.104
Adj R-squared	0.267	0.246	0.012	0.058	0.088	0.018	0.202	0.043
Panel C: Information Leadership Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.617	0.322	0.344	0.333	0.187	0.072	0.627	0.789
Ind Spread	-0.039	-0.001	0.021	0.023	0.066	0.094	0.000	-0.004
N of Ind Quotations	-0.005	0.007	0.001	0.003	0.000	0.004	-0.004	-0.001
Volatility	0.123	-0.032	0.029	-0.333	-0.260	-2.901	-0.177	-0.032
Asian & London TS	-0.006	0.026	-0.004	0.005	-0.005	-0.010	-0.010	0.089
London & US TS	0.007	-0.102	-0.006	-0.007	-0.017	-0.010	-0.027	0.003
Adj R-squared	0.093	0.328	0.023	0.044	0.055	0.079	0.123	0.1767

Next, it is worthwhile to elaborate on the effect of market variables on the price discovery characteristics of the indicative quotes. Regarding volatility, it is seen that the volatility ratio is negatively related with the price discovery share of the indicative quotes. When the dependent variable is component or information share measures, the volatility ratio is found to be significant and inversely related with the related price discovery measure for almost all of the currency pairs. The results imply that when the volatility of the indicative series increase with subject to the volatility of the tradeable series, the price discovery share of the indicative (tradeable) series decrease (increase). As Reuters Matching Platform is regarded as one of the primary ECN's, the negative

significant coefficients of volatility ratio support this view expressed in the BIS Report. However, this support is subdued if we consider the results for information leadership measure where the volatility ratio is significant for only two currencies (GBP/USD and USD/CAD).

Table 5.8

Summary of Model 1 Results – Local Market Hours

This table presents the coefficients of Model-1 using only local market hours as the sample. Bold coefficients are significant at an alpha level of 10 percent or better. Panel A shows the results for component share. Panel B gives the results for information share. Panel C gives the results for information leadership share. Variable definitions are given in Table 5.3.

Panel A: Component Share Measure					
	MXN	AUD	CAD	NZD	SGD
Constant	0.159	0.063	-0.02	-0.096	0.185
Indicative Spread	0.000	-0.003	0.01	0.077	0.021
N of Indicative Quotations	-0.002	0.001	0.00	-0.002	-0.021
Volatility	-0.157	0.001	0.00	0.015	0.554
Adjusted R-squared	0.189	0.000	0.130	0.026	0.088
Panel B: Information Share Measure					
	MXN	AUD	CAD	NZD	SGD
Constant	0.102	0.034	-0.024	-0.110	0.045
Indicative Spread	0.000	0.006	0.009	0.076	0.055
N of Indicative Quotations	0.000	0.002	0.000	-0.001	-0.016
Volatility	-0.128	0.002	-0.010	-0.001	0.073
Adjusted R-squared	0.070	0.060	0.110	0.016	0.111
Panel C: Information Leadership Share Measure					
	MXN	AUD	CAD	NZD	SGD
Constant	0.223	0.328	0.310	0.413	0.138
Indicative Spread	0.000	0.032	0.023	0.000	0.080
N of Indicative Quotations	0.009	0.002	0.004	0.000	0.005
Volatility	-0.208	0.003	-0.350	-0.048	-1.107
Adjusted R-squared	0.414	0.039	0.021	0.000	0.087

Considering the bid-ask spreads, for most of the currency pairs it is observed that in Model 1, the indicative spread is negatively related with the price discovery share of the indicative quotes, while in Model 2 the tradeable spread is positively related with the price discovery share of the tradeable quotes. Recall that the spread ratio is calculated by dividing the indicative bid-ask spread by the tradeable bid-ask spread. So, the higher the ratio, the larger the spread in the indicative quotes relative to the tradeable quotes. A dealer would increase the size of the bid-ask spread when there is more noise, more volatility, and less liquidity in the market. So, when the indicative

spread gets larger in comparison to the tradeable spread, the information content of the indicative prices goes down. At the same time, when the indicative spread gets larger in comparison to the tradeable spread, the information content of the tradeable prices increases.

Table 5.9
Summary of Model 2 Results – Full Sample

This table presents the coefficients of Model-2 for all the exchange rates. Bold coefficients are significant at an alpha level of 10 percent or better. Panel A shows the results for component share. Panel B gives the results for information share. Panel C gives the results for information leadership share. In Model 2, the dependent variable is the price discovery measure of the tradeable series. Variable definitions are given in Table 5.3.

Panel A: Component Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.875	0.728	0.968	0.953	0.892	0.904	0.502	0.817
Trd Spread	-0.008	0.001	-0.015	0.003	0.009	-0.004	0.000	0.000
N of Trd Quotations	0.010	0.011	0.001	0.011	0.000	-0.023	0.002	0.012
Trd Volatility	-0.033	-0.027	-0.002	-0.562	-0.027	0.000	-0.017	-0.040
Only Asian TS	-0.051	-0.060	-0.015	-0.019	-0.036	-0.039	0.185	-0.038
Asian & London TS	0.003	0.004	0.001	-0.008	-0.004	-0.005	0.060	-0.026
London & US TS	-0.014	0.042	-0.005	0.000	0.008	-0.008	0.102	-0.101
Only US TS	-0.040	0.049	-0.020	0.004	-0.023	-0.060	0.134	-0.119
Adj R-squared	0.298	0.165	0.159	0.229	0.162	0.470	0.177	0.144
Panel B: Information Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.837	0.571	0.977	0.952	0.896	0.888	0.465	0.742
Trd Spread	0.008	0.001	-0.016	0.001	0.013	-0.002	0.000	0.000
N of Trd Quotations	0.009	0.036	-0.001	0.016	0.001	-0.014	0.026	0.079
Trd Volatility	-0.033	-0.121	-0.003	-0.748	-0.028	0.000	-0.011	-0.040
Only Asian TS	-0.061	0.002	-0.016	-0.018	-0.033	-0.043	0.125	-0.062
Asian & London TS	0.002	-0.010	0.001	-0.009	-0.003	-0.004	0.053	-0.056
London & US TS	-0.012	0.005	-0.001	-0.002	0.010	-0.006	0.095	-0.093
Only US TS	-0.048	0.059	-0.015	0.005	-0.016	-0.050	0.121	-0.164
Adj R-squared	0.264	0.109	0.145	0.191	0.135	0.285	0.104	0.078
Panel C: Information Leadership Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.473	0.272	0.633	0.624	0.555	0.525	0.402	0.326
Trd Spread	0.041	-0.001	-0.021	-0.029	0.027	0.004	0.000	0.001
N of Trd Quotations	0.004	-0.011	-0.005	0.009	0.006	0.033	0.041	0.205
Trd Volatility	-0.007	0.027	-0.002	-0.316	-0.010	0.000	0.048	-0.019
Only Asian TS	-0.055	0.060	-0.006	0.014	-0.014	-0.027	-0.108	0.018
Asian & London TS	-0.001	-0.004	0.001	-0.007	-0.005	-0.020	-0.001	-0.084
London & US TS	0.000	-0.042	0.014	0.001	0.016	-0.004	0.013	0.016
Only US TS	-0.049	-0.049	0.019	0.021	0.007	-0.002	-0.003	-0.069
Adj R-squared	0.250	0.165	0.100	0.050	0.054	0.347	0.193	0.146

This result implies that during times of high noise, high volatility, and low liquidity, the tradeable quotes have a relatively larger information share compared to indicative quotes.

Table 5.10

Summary of Model 2 Results – London Market Hours

This table presents the coefficients of Model-2 using only London market hours as the sample. Bold coefficients are significant at an alpha level of 10 percent or better. Panel A shows the results for component share. Panel B gives the results for information share. Panel C gives the results for information leadership share. In Model 2, the dependent variable is the price discovery measure of the tradeable series. Variable definitions are given in Table 5.3.

Panel A: Component Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.898	0.776	0.972	0.989	0.882	0.901	0.369	0.878
Trd Spread	-0.021	0.000	-0.018	-0.003	0.015	-0.004	0.001	-0.001
N of Trd Quotations	0.019	0.011	-0.001	-0.001	0.009	-0.002	0.075	0.049
Trd Volatility	-0.138	0.003	0.105	-0.084	-0.172	-0.169	0.070	-0.012
Asian & London TS	0.003	0.012	0.002	-0.006	-0.005	-0.011	0.046	-0.020
London and US TS	-0.025	0.022	-0.005	0.004	0.006	-0.014	0.095	-0.074
Adj R-squared	0.168	0.096	0.049	0.075	0.081	0.508	0.226	0.091
Panel B: Information Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.839	0.643	0.988	0.984	0.909	0.885	0.341	0.805
Trd Spread	0.007	0.000	-0.026	-0.001	0.004	-0.001	0.001	-0.001
N of Trd Quotations	0.020	0.029	-0.004	-0.001	0.014	0.008	0.116	0.091
Trd Volatility	-0.242	-0.018	0.159	-0.122	-0.221	-0.224	-0.001	-0.011
Asian & London TS	0.001	0.002	0.002	-0.006	-0.005	-0.010	0.042	-0.051
London & US TS	-0.022	-0.016	0.000	0.004	0.006	-0.012	0.088	-0.076
Adj R-squared	0.124	0.123	0.055	0.072	0.079	0.393	0.240	0.016
Panel C: Information Leadership Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.421	0.224	0.675	0.625	0.659	0.525	0.409	0.316
Trd Spread	0.071	0.000	-0.055	-0.024	-0.034	0.006	0.000	0.001
N of Trd Quotations	0.009	-0.011	-0.010	0.001	0.020	0.037	0.083	0.139
Trd Volatility	-0.316	-0.003	0.243	-0.079	-0.130	-0.092	-0.070	0.006
Asian & London TS	-0.004	-0.012	0.002	-0.006	-0.006	-0.019	0.002	-0.084
London & US TS	-0.002	-0.022	0.018	0.005	0.008	-0.005	0.012	-0.003
Adj R-squared	0.108	0.096	0.079		0.056	0.390	0.222	0.206

Also, the tradeable spread is usually positive and significant and indicative spread is usually negative if the dependent variable is the information leadership measure. Similarly, for most of the currencies it is seen that the spread ratio is inversely related with the component and information shares of the indicative series. On the other hand, spread ratio is found to be positively related with the information leadership measure

of the indicative series (except for USD/MXN). This difference may be due to the focus of the price discovery measures in the sense that information leadership measure focuses only on the speed of information while the spread ratio mostly represents the noise and volatility level in the market.

Table 5.11
Summary of Model 2 Results – Local Market Hours

This table presents the coefficients of Model-2 using only local market hours as the sample. Bold coefficients are significant at an alpha level of 10 percent or better. Panel A shows the results for component share. Panel B gives the results for information share. Panel C gives the results for information leadership share. In Model 2, the dependent variable is the price discovery measure of the tradeable series. Variable definitions are given in Table 5.3.

Panel A: Component Share Measure					
	MXN	AUD	CAD	NZD	SGD
Constant	0.835	0.951	1.003	0.854	0.815
Tradeable Spread	0.000	-0.015	-0.003	0.008	-0.005
N of Tradeable Quotations	0.013	0.001	0.003	-0.002	-0.012
Tradeable Volatility	-0.135	-0.002	-0.286	-0.023	0.000
Adj R-squared	0.010	0.000	0.200	0.013	0.458
Panel B: Information Share Measure					
	MXN	AUD	CAD	NZD	SGD
Constant	0.650	0.957	1.001	0.854	0.792
Tradeable Spread	0.001	-0.014	-0.002	0.016	-0.003
N of Tradeable Quotations	0.010	-0.001	0.004	-0.003	-0.005
Tradeable Volatility	0.011	-0.002	-0.354	-0.023	0.000
Adj R-squared	0.027	0.019	0.189	0.006	0.304
Panel C: Information Leadership Share Measure					
	MXN	AUD	CAD	NZD	SGD
Constant	0.650	0.617	0.669	0.532	0.487
Tradeable Spread	0.001	-0.014	-0.033	0.032	0.003
N of Tradeable Quotations	0.010	-0.004	-0.004	0.003	0.025
Tradeable Volatility	0.011	-0.003	-0.041	-0.006	0.000
Adj R-squared	0.030	0.036	0.00	0.000	0.188

Findings about the effect of the spread ratio are interesting and also robust to sample changes. It is possible to argue that this is due to the fragmented structure of the FX market. Osler (2011)'s model demonstrates that price discovery in the interbank market (Stage-2 of the price discovery process) is expected follow the standard paradigm that is defined as market makers will widen their bid-ask spreads when they can identify better informed customers. However, in Stage-1 of the model, bid-ask spreads are narrow even in the presence of private information. Market practices

suggest that dealers promote their large inventory positions to informed customers at narrower bid-ask spreads in order to clear an inventory position without trading in the interdealer markets. Thus, Stage-1 of the model acts as a dealer-customer segment.

Table 5.12
Summary of Model 3 Results – Full Sample

This table presents the coefficients of Model-3 for all the exchange rates. Bold coefficients are significant at an alpha level of 10 percent or better. Panel A shows the results for component share. Panel B gives the results for information share. Panel C gives the results for information leadership share. Variable definitions are given in Table 5.3.

Panel A: Component Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.313	0.194	0.054	0.116	0.138	0.379	0.696	0.394
Spread Ratio	-0.067	-0.017	-0.011	-0.029	0.009	-0.081	-0.078	-0.161
Ratio of No of Quot	-0.001	0.000	-0.001	0.001	-0.004	-0.023	0.000	0.000
Volatility Ratio	-0.110	-0.008	0.015	-0.019	-0.029	-0.029	-0.169	-0.005
Trade Ratio	0.061	0.166	0.021	0.018	-0.009	-0.043	0.094	-0.048
Only Asian TS	0.044	0.063	0.012	0.011	0.033	0.052	-0.174	0.122
Asian & London TS	-0.007	-0.011	-0.001	-0.001	0.003	0.034	-0.056	0.027
London & US TS	0.004	-0.055	0.001	-0.013	-0.015	0.002	-0.102	0.087
US Trading TS	0.040	-0.051	0.015	-0.016	0.022	0.045	-0.129	0.174
Adj R-squared	0.29	0.240	0.160	0.379	0.260	0.414	0.301	0.169
Panel B: Information Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.287	0.138	0.037	0.106	0.108	0.272	0.612	0.335
Spread Ratio	-0.036	-0.029	-0.014	-0.018	0.009	-0.042	0.027	-0.086
Ratio of No of Quot	0.001	0.003	-0.005	0.001	-0.002	-0.010	0.000	0.000
Volatility Ratio	-0.129	-0.008	0.049	-0.022	-0.029	-0.027	-0.162	-0.004
Trade Ratio	0.025	0.157	0.006	0.003	0.029	-0.034	0.084	-0.013
Only Asian TS	0.051	0.029	0.016	0.015	0.030	0.053	-0.129	0.116
Asian & London TS	-0.005	-0.010	0.001	-0.001	0.002	0.023	-0.054	0.045
London & US TS	0.005	-0.042	-0.002	-0.012	-0.014	0.002	-0.097	0.087
US TS	0.046	-0.044	0.010	-0.013	0.018	0.042	-0.112	0.189
Adj R-squared	0.260	0.195	0.159	0.289	0.208	0.210	0.159	0.064
Panel C: Information Leadership Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.338	0.285	0.274	0.405	0.327	0.193	0.370	0.348
Spread Ratio	0.084	-0.070	-0.005	0.023	0.005	0.073	0.213	0.154
Ratio of No of Quot	0.005	0.014	-0.007	0.005	0.006	0.037	0.000	0.000
Volatility Ratio	-0.053	-0.003	0.175	-0.014	-0.005	-0.003	-0.021	0.003
Trade Ratio	-0.112	0.111	-0.075	-0.045	0.164	0.046	-0.009	0.149
Only Asian TS	0.044	-0.061	0.014	-0.012	0.013	0.026	0.062	-0.052
Asian & London TS	0.003	0.004	0.004	0.005	0.003	-0.003	-0.010	0.041
London & US TS	0.007	-0.022	-0.010	-0.003	-0.010	0.011	-0.018	0.003
US TS	0.042	-0.058	-0.021	-0.017	-0.001	0.026	0.004	0.035
Adj R-squared	0.290	0.38	0.070	0.065	0.068	0.341	0.136	0.108

Therefore, based on the results of the information leadership measure, it can be argued that the Reuters Matching platform acts as an interdealer platform and spreads follow the predictions of Osler's model for Stage-2 of the price discovery process where the EFX quotations act similar to the dealer-customer segment of the FX market.

Table 5.13

Summary of Model 3 Results – London Market Hours

This table presents the coefficients of Model-3 using only London market hours as the sample. Bold coefficients are significant at an alpha level of 10 percent or better. Panel A shows the results for component share. Panel B gives the results for information share. Panel C gives the results for information leadership. Variable definitions are given in Table 5.3.

Panel A: Component Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.390	0.293	0.112	0.08	0.151	0.373	0.760	0.448
Spread Ratio	-0.035	-0.060	-0.005	-0.01	0.010	-0.067	-0.059	-0.261
Ratio of No of Quot	0.005	0.001	0.002	0.00	-0.001	-0.020	0.004	0.000
Volatility Ratio	-0.244	-0.045	-0.069	-0.02	-0.061	-0.052	-0.401	-0.009
Trade Ratio	-0.076	0.206	0.033	0.02	0.027	-0.029	0.147	-0.055
Asian & London TS	-0.010	-0.009	-0.002	0.00	0.003	0.028	-0.041	0.027
London & US TS	0.005	-0.071	0.004	-0.01	-0.012	0.002	-0.100	0.064
Adj R-squared	0.247	0.382	0.024	0.331	0.214	0.338	0.286	0.201
Panel B: Information Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.390	0.219	0.103	0.077	0.145	0.265	0.653	0.355
Spread Ratio	-0.035	-0.064	-0.007	-0.009	-0.003	-0.032	-0.078	-0.153
Ratio of No of Quot	0.005	0.004	-0.003	-0.001	0.002	-0.008	0.005	0.000
Volatility Ratio	-0.244	-0.035	-0.036	-0.016	-0.064	-0.046	-0.351	-0.009
Trade Ratio	-0.076	0.144	0.013	0.024	0.069	-0.019	0.258	-0.042
Asian & London TS	-0.010	-0.008	0.000	0.002	0.003	0.018	-0.033	0.044
London & US TS	0.005	-0.051	0.000	-0.013	-0.010	0.002	-0.094	0.055
Adj R-squared	0.247	0.309	0.015	0.313	0.200	0.144	0.274	0.084
Panel C: Information Leadership Share Measure								
	GBP	MXN	AUD	CAD	NZD	SGD	ZAR	TRY
Constant	0.340	0.312	0.383	0.400	0.416	0.171	0.473	0.295
Spread Ratio	0.094	-0.086	-0.011	0.026	-0.046	0.070	-0.041	0.208
Ratio of No of Quot	0.005	0.017	-0.018	0.005	0.013	0.038	0.003	0.000
Volatility Ratio	-0.073	-0.006	0.111	-0.016	-0.040	0.007	-0.091	0.001
Trade Ratio	-0.195	-0.124	-0.073	-0.056	0.228	0.036	0.157	0.082
Asian and London TS	0.001	0.001	0.005	0.005	0.006	0.000	0.005	0.047
London and US TS	0.009	0.001	-0.015	-0.003	-0.002	0.012	-0.015	-0.017
Adj R-squared	0.073	0.399	0.069	0.038	0.112	0.301	0.211	0.135

This argument is also in line with Lyons (2001) who claims that indicative prices are provided for non-dealer customers and with Goodhart and O'hara (1997) who argue

that the end-users of indicative quotes are usually non-bank users such as non-bank companies and public sector bodies.

Table 5.14
Summary of Model 3 Results – Local Market Hours

This table presents the coefficients of Model-3 using only local market hours as the sample. Bold coefficients are significant at an alpha level of 10 percent or better. Panel A shows the results for component share. Panel B gives the results for information share. Panel C gives the results for information leadership share. Variable definitions are given in Table 5.3.

Panel A: Component Share Measure					
	MXN	AUD	CAD	NZD	SGD
Constant	0.195	-0.101	0.00	0.155	0.594
Spread Ratio	-0.041	-0.006	0.009	0.046	-0.117
Ratio of Number of Quotations	-0.001	-0.003	0.001	-0.008	-0.045
Volatility Ratio	-0.027	0.198	-0.006	-0.038	-0.031
Trade Ratio	0.003	-0.031	-0.009	-0.065	-0.032
Adj R-squared	0.227	0.023	0.166	0.100	0.462
Panel B: Information Share Measure					
	MXN	AUD	CAD	NZD	SGD
Constant	0.131	-0.071	0.001	0.124	0.502
Spread Ratio	-0.041	-0.016	0.013	0.047	-0.073
Ratio of Number of Quotations	0.003	-0.006	0.001	-0.005	-0.034
Volatility Ratio	-0.020	0.190	-0.007	-0.044	-0.031
Trade Ratio	-0.012	-0.021	-0.006	-0.030	-0.049
Adj R-squared	0.126	0.080	0.155	0.073	0.296
Panel C: Information Leadership Share Measure					
	MXN	AUD	CAD	NZD	SGD
Constant	0.217	0.309	0.347	0.345	0.314
Spread Ratio	-0.039	-0.012	0.054	0.007	0.072
Ratio of Number of Quotations	0.025	-0.004	0.006	0.010	0.021
Volatility Ratio	-0.013	0.138	-0.021	-0.023	-0.011
Trade Ratio	-0.014	-0.014	-0.036	0.146	-0.011
Adj R-squared	0.411	0.001	0.053	0.014	0.173

Related to the variables about market activity, it is observed that the ratio of number of quotations is generally insignificant for component and information share measures. Also, it is inversely related with these measures when it is significant. However, it is significant and positively related with the information leadership of the indicative series. As explained in Chapter 4, the component and information share measures focus on noise and speed in terms of price discovery. Hence, due to the adjustment for noise during the calculation of these measures, the magnitude of these measures decreases

as the number of quotations in the indicative series increases.

On the other hand, since the information leadership measure focuses just on the speed of price discovery, an increase in the number of quotations in indicative series compared to the number of quotations in tradeable series leads to an increase in the information leadership measure since quotations convey new information about the level of the exchange rate. Another trading activity variable included in the models is the trade ratio; however, this variable does not seem to have a significant effect on any of the price discovery measures.

Next, it should be noted that the findings discussed above are not derived by trading session effects. The findings imply that the direction of the relationships and their significance do not change drastically if the sample is changed to include only the London market or the local market trading hours. However, this observation does not mean that trading session effects are insignificant. As a matter of fact, the trading session variables have a significant effect on the component and information share measures.

As the literature suggests, the price discovery process is affected from trading sessions and heterogeneity of investors in different locations. For example, for most of the currencies, the trading activity is dominated with cross-border trades from international financial institutions and large dealers during the London and US trading hours while in local market hours, local banks dominate the trading activity. As the trading styles, purposes and information sets of these market players are different, it is plausible to expect the trading sessions to affect the price discovery shares of indicative/tradeable quotations since these two quotations typically represent different market players. The Reuters Matching platform is generally used by financial institutions and dealers while indicative quotations are quoted by dealers or local banks. Therefore, in line with these arguments, it is expected that the price discovery share of the tradeable quotations should be highest during the London trading hours.

In parallel, it is observed that the price discovery share of indicative quotations are higher for Asian trading hours especially for currencies when the Asian local market

is open. It may be argued that this finding is driven by the increase in activity in the Reuters Matching system, but it is robust even when the information leadership measure results are considered for the other significant market variables (spread and ratio of the number of quotations).

Findings related to the US trading hours are somewhat mixed. It is observed that the price discovery share of indicative quotes are lower for the currencies when both their local markets and the US market are open at the same time (for MXN and CAD), and higher for the currencies when both their local markets and the London market are closed (GBP, SGD) even when the information leadership measure is considered.

5.4 Robustness Checks

Related to the analysis on price discovery measures, to examine whether the price discovery measures are different when the measures are estimated for longer periods than a slice in a day, the price discovery measures are re-calculated for each of the currency pairs for on-hours of the day. Table 5.15 shows that results are similar to the average of day/slice results, implying that the original results are robust to changes in the selection of calculation periods.

Related to the analysis on price discovery measures, it is checked to see whether a different sampling frequency would change the results. For GBP/USD and USD/MXN, the price discovery metrics are re-calculated after changing the sampling frequency to event time. When sampling is based on the event time for tradeable quotes, this change leads to a decrease in the price discovery share of tradeable quotations. On the other hand, when sampling is based on the event time for indicative quotes, this change leads to an increase in the price discovery share of indicative prices. These results imply that using event time sampling based on the tradeable quotations leads to information loss in comparison to the frequently updated indicative quotations.

Table 5.15**Price Discovery Measure Estimations for Longer Time Period**

This table shows the estimated price discovery measures for on-hours and local times during the work weeks. Panel A shows the results for component share. Panel B gives the results for information share. Panel C gives the results for information leadership share.

Panel A: Component Shares of Indicative Quotations								
Time Period	AUD	CAD	GBP	MXN	NZD	SGD	TRY	ZAR
13-21 August	0.03	0.01	0.08	0.09	0.10	0.13	0.27	0.13
21-29 August	0.06	0.01	0.15	0.13	0.12	0.13	0.24	0.24
1-5 September	0.07	0.01	0.18	0.01	0.10	0.13	0.22	0.36
7-12 September	0.06	0.01	0.16	0.16	0.10	0.16	0.24	0.30
14-19 September	0.06	0.01	0.16	0.22	0.13	0.14	0.27	0.43
21-26 September	0.05	0.02	0.13	0.01	0.13	0.16	0.33	0.49
28-31 September	0.06	0.01	0.13	0.05	0.09	0.10	0.30	0.39
Average	0.06	0.01	0.14	0.10	0.11	0.14	0.27	0.33
Panel B: Information Shares of Indicative Quotations								
Time Period	AUD	CAD	GBP	MXN	NZD	SGD	TRY	ZAR
13-21 August	0.06	0.01	0.11	0.09	0.12	0.16	0.25	0.14
21-29 August	0.09	0.01	0.18	0.10	0.12	0.16	0.21	0.25
1-5 September	0.08	0.01	0.19	0.01	0.11	0.14	0.17	0.34
7-12 September	0.07	0.02	0.18	0.14	0.09	0.15	0.21	0.33
14-19 September	0.10	0.02	0.16	0.13	0.18	0.21	0.30	0.43
21-26 September	0.11	0.02	0.13	0.01	0.14	0.19	0.29	0.48
28-31 September	0.08	0.01	0.11	0.03	0.08	0.11	0.25	0.39
Average	0.08	0.02	0.15	0.07	0.12	0.16	0.24	0.34
Panel C: Information Leadership Shares of Indicative Quotations								
Time Period	AUD	CAD	GBP	MXN	NZD	SGD	TRY	ZAR
13-21 August	0.48	0.44	0.46	0.40	0.45	0.48	0.45	0.47
21-29 August	0.46	0.45	0.46	0.32	0.45	0.48	0.48	0.48
1-5 September	0.42	0.42	0.45	0.30	0.44	0.45	0.42	0.44
7-12 September	0.44	0.45	0.46	0.39	0.40	0.44	0.48	0.53
14-19 September	0.48	0.49	0.43	0.26	0.49	0.50	0.64	0.49
21-26 September	0.48	0.46	0.43	0.28	0.45	0.49	0.31	0.49
28-31 September	0.45	0.43	0.39	0.32	0.41	0.46	0.26	0.49
Average	0.46	0.45	0.44	0.33	0.44	0.47	0.43	0.48

CHAPTER 6

CONCLUSION

This study provides a comprehensive analysis of the price discovery process in the FX market by comparing indicative quotes from the Reuters EFX page with tradeable quotes from the Reuters Matching System. The research results provide a resolution for the previous contradicting findings in the existing literature and offers new insights into the dynamics of price discovery in a highly fragmented and evolving FX market.

First, by utilizing updated data, the prevailing uncertainty regarding which market platform leads in price discovery is clarified. The findings indicate that the Reuters Matching System generally dominates price discovery. This dominance is evidenced by the substantial variation in currency pairs, particularly when considering the information and component share measures. However, it should be noted that indicative quotes also play a significant role, with their information leadership shares reaching at least 40% in most exchange rates. This suggests that a considerable portion of new information is first incorporated into indicative quotations.

The significant differences observed between the estimated price discovery measures underscore the importance of selecting appropriate metrics, especially when there are varying degrees of noise between the price series. These findings corroborate Putnins' (2013) argument that noise levels must be carefully considered in the selection of price discovery measures.

The study also identifies the determinants of price discovery, revealing that the bid-ask spread ratio, the ratio of the number of quotations, and the volatility ratio are significant market variables influencing price discovery between indicative and

tradeable quotations. The volatility ratio, particularly significant for the component and information share measures, is negatively related to the price discovery share of indicative quotes, likely due to its focus on the noisiness of the series. Conversely, the number of quotations ratio is positively related to the information leadership share, suggesting that trading activity helps to convey new information about exchange rates.

Furthermore, the bid-ask spread ratio is shown to have a negative effect on the component and information shares of indicative series for most currencies but a positive effect on the information leadership measure. This divergence in results stems from the different focuses of price discovery measures: the information leadership measure, by emphasizing the speed of information, can better identify the impact of tradable spreads on the price discovery of indicative and tradeable quotes. The results suggest that the Reuters Matching System functions as an interdealer platform, with bid-ask spreads following Osler et al's (2011) model, where market makers widen their spreads when they identify better-informed customers.

Additionally, the study underscores the importance of trading session variables in the price discovery of indicative and tradeable quotations. These variables are particularly significant for the component and information share measures, reflecting the importance of taking into account whether different markets are in session (such as London, US, or local markets) while evaluating the price discovery process.

In conclusion, this study significantly contributes to the understanding of price discovery in the FX market by providing a detailed comparison of tradeable and indicative quotes. By examining a detailed updated data set, valuable insights are provided into the roles played by indicative and tradeable quotations and market variables in the price discovery process. The findings show the importance of volatility, trading activity and bid-ask spreads in terms of price discovery in the FX market. Furthermore, the findings of this study highlight the importance of selecting the appropriate price discovery metrics. This research not only resolves previous contradictions in the literature but also paves the way for future studies to explore the evolving dynamics of price discovery in decentralized markets.

The findings of this study also have important policy implications for regulators and central banks. An important role of regulators is market monitoring and surveillance for the orderly functioning of markets. The findings highlight that it is important to monitor market prices gathered from not only major ECNs but also from indicative quotations to grasp a complete picture of the market. Also, policy makers should take into account the effect of trading zones in the price discovery process and increase their focus on indicative quotations when major financial markets are closed. The findings also have important implications for central banks regarding FX interventions. As the findings suggest that the dominant locations for price discovery is a primary ECN and bid-ask spreads are positively related with the price discovery in this platform, when intervening in the FX market central banks should consider intervening via a primary ECN if they pursue to create a significant price effect and prefer to be known while intervening. On the other hand, if they prefer to remain hidden, they should intervene using multiple market players and should not use a primary ECN.

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APPENDICES

A. DISCUSSION OF INDIVIDUAL CURRENCY PAIR REGRESSION ESTIMATIONS

A.1 GBP/USD Regressions

Tables A.1.1 to A.3.1 show the regression results where the dependent variable is the component share, information share and information leadership share measures for GBP/USD, respectively.

Results show that the indicative spread and the number of indicative quotations have a significant and negative effect on the component share of indicative prices. The same relationships are not significant for the tradeable prices. While we do not find a significant effect of tradeable spread and volatility on the component share measure of the tradeable quote series; on the other hand, we find the number of tradeable quotations is positively related with that series price discovery measure. Regression based on ratios show that spread ratio and volatility ratio is significant and negatively related with the component share measure of the indicative series. The findings are similar when the sample is limited to time slices when London trading is on or we change trading session dummies, except the spread ratio becomes insignificant while the ratio of number of quotations becomes significant and positively related in time slices where London trading is on. Results show that component share of the indicative series is lower in London trading session. Results based on information share measure show that indicative spread and number of indicative quotations are significant and inversely related with the information share measure of the indicative series. We find the number of tradeable quotations is positively related with that series price discovery measure. Regression based on ratios show volatility ratio is significant and negatively related with the information share measure of the indicative series. The findings are

similar when the sample is limited to time slices when London trading is on or we change trading session dummies, except the ratio of number of quotations becomes significant and positively related in time slices where London trading is on. Results show that information share of the indicative series is lower in London trading session especially in the Asian-London trading hours. Results based on information leadership share measure show that indicative spread, and the number of indicative quotations is significant and inversely related with the information leadership share measure of the indicative series. Tradeable spread is found to be positively related whereas volatility is negatively related with the information leadership share measure of the tradeable quotes. Regression based on ratios show spread ratio and ratio of number of quotations are significant and positively related while volatility ratio is significant and negatively related with the information share of the indicative quotes. The findings are similar when the sample is limited to time slices when London trading is on or we change trading session dummies; however, instead of volatility ratio, trade ratio becomes significant and negatively related with the price discovery measure in time slices where London trading is on. We find evidence for higher information leadership of indicative quotes in US trading session.

A.2 USD/MXN Regressions

Tables A.2.1 to A.2.3 show the regression results where the dependent variable is the component share, information share and information leadership share measures for USD/MXN, respectively. Results based on component share measure shows that indicative spread has significant positive effect, while the number of indicative quotations and volatility has significant negative effect on the component share of indicative quotes. On the other hand, tradeable spread and number of tradeable quotations are found to be positively related with the component share of firm quotes. Regression based on ratios show that spread ratio significant and negatively related with the component share measure only for London and local market hours while negative effect of volatility is valid for all of the sample selection.

Results show that component share of the indicative series is lower in London and US

trading session, while it is higher for Asian trading session. Results based on information share measure shows that indicative spread is insignificant while the number of quotations and volatility is negatively related with the information share of the indicative series. On the other hand, tradeable spread and the number of tradeable quotations have a positive, volatility has a negative effect on the information share of the firm quotes. Regression based on ratios show that spread ratio and volatility ratio is significant and negatively related with the information share measure, while ratio of number of quotations is positively related. Results show that information share of the indicative series is lower in London and US trading session, while it is higher for Asian trading session. Results based on information leadership share measure shows that, indicative spread has significant negative effect, while the number of indicative quotations has significant positive effect on the component share of indicative quotes. Volatility is found to be significant and negatively related in only regression based on local hours. Regression based on ratios show that spread ratio is inversely and the ratio of number of quotations is positively related with the information leadership share of the indicative series. Volatility becomes significant in only local market hours. Information leadership share of indicative quotes is found to be lower in US trading session.

A.3 AUD/USD Regressions

Tables A.3.1-A.3.3 shows the regression results where dependent variable is component share, information share and information leadership share respectively for AUD/USD. Results based on component share measure shows that in overall, market variables are insignificant in explaining the variation in the component share measure. We do not find significant coefficients for the regression based on ratios in general as well. The results imply that price discovery share of indicative quotes is higher for the Asian and US trading sessions. Similarly, the market variables are insignificant in explaining the variation in the information share measure except the number of quotations. We find that the ratio of the number of quotations is negatively related with the information share measure of the indicative quotes. The positive contribution of Asian and US trading sessions is valid in the case of information share measure too.

Results based on information leadership share measure shows that indicative spread, number of quotations and volatility has significant effect on information leadership of indicative series. However, considering all of the models, we find that there is only significant effect of trading activity on information leadership measure. We find significant positive effect of Asian session, and significant and negative effect of US trading session.

A.4 USD/CAD Regressions

Tables A.4.1- A.4.3 shows the regression results where dependent variable is component share, information share and information leadership share respectively for USD/CAD.

Results based on component share measure shows that indicative spread and the number of indicative quotations are significant in Model-1 but the significance of the variables change when we change the sample. Models based on ratios show that only is significant in explaining the variation in component share measure. We find significant negative effect of London and US and US only trading session. We find similar results based on information share measure. Considering information leadership share measure we find significant and negative effect of volatility ratio and positive effect of ratio of number of quotations especially for local market hours. We do not find significant market session effects on information leadership measure.

A.5 NZD/USD Regressions

Tables A.5.1-A.5.3 shows the regression results where dependent variable is component share, information share and information leadership share respectively for NZD/USD. Results based on component share measure shows that in overall, only tradeable volatility is significant in Model-1 and Model-2. Regression based on ratios show that number of quotations ratio and volatility ratio has a negative effect on the component share of indicative series. However, volatility seems to have effect on London market hours only while ratio of quotations seems to have effect on local market hours specifically. The results imply that price discovery share of indicative quotes is higher for the Asian and US trading sessions and lower when London and

US are both open. Similarly, results based on information share measure shows only tradeable spread and volatility is significant in Model-1 and Model-2. However, in regressions based on ratios, volatility ratio is found to be significant and inversely related with the information share of the indicative quotes. Trade ratio is positive and significant in regression based on London market hours.

Results based on information leadership share measure shows that in overall, market variables are insignificant in explaining the variation in the information leadership share measure. Only trade ratio is found to be significant (positive) effect on the information leadership of the indicative quotes. However, when we analyze London market trading hours only, we see that spread ratio and volatility ratio has a negative effect and ratio of number of quotations and trade ratio has a positive effect on information leadership of the indicative quotes. When we focus on only local market hours, we see that only number of quotations and trade ratio has a positive significant effect. We find significant positive effect of Asian session on the information leadership share of indicative quotes.

A.6 USD/SGD Regressions

Tables A.6.1-A.6.3 shows the regression results where dependent variable is component share, information share and information leadership share respectively for USD/SGD. Results based on component share measure show that volatility positively affects the component share measure of the indicative series while tradeable spread and number of tradeable quotations are inversely related with the component share measure of the indicative quotes. Considering regressions based on ratios, we find that spread ratio, number of quotations ratio and volatility ratio have all significant and negative effect on the component share of the indicative quotes, and this is robust to sample and trade session dummy variable changes. We find evidence of higher component share of indicative series in Asian and US trading hours. Results based on information share measure show that that spread ratio, number of quotations ratio and volatility ratio have all significant and negative effect on the information share of the indicative quotes; however, spread ratio becomes insignificant when we use London market and local market trading hours. Volatility ratio seems to be robust to sample

changes. Also, information share of indicative series is found to be higher in Asian and US trading hours as well. Considering information leadership share, we find that indicative spread and tradeable spread both positively affects the information leadership share of the related series.

The volatility of the indicative series negatively affects and volatility of the tradeable series positively affects the information leadership share of the related series. Regressions based on ratios show that spread ratio and ratio of number of quotations both positively affects the leadership share of the indicative quotes and this finding is robust to change in sample. Also, information leadership share of indicative series is found to be higher in Asian and US trading hours.

A.7 USD/ZAR Regressions

Tables A.7.1-A.7.3 shows the regression results where dependent variable is component share, information share and information leadership share respectively for USD/ZAR.

Results based on component share measure shows that indicative spread and volatility (in London market only) are significant in Model-1 in explaining the variation in the component share of the indicative series. Models based on ratios show that volatility ratio has a significant negative effect on the component share of the indicative series. On the other hand, when we use sample only on London market hours ratio of number of quotations becomes significant.

Information share results are similar in the sense that only volatility ratio is significant in explaining the variation in the information share measure. Considering regression based on London market hours, we find ratio of number of quotations has positive, volatility ratio has negative, and trade ratio has positive effect on the information leadership share of the indicative quotes. We find evidence of higher component and information share of the indicative quotations in London trading hours but trading session affect is not significant in information leadership share measure.

A.8 USD/TRY Regressions

Tables A.8.1-A.8.3 shows the regression results where dependent variable is component share, information share and information leadership share respectively for USD/TRY. Results based on component share measure shows that volatility is significant and negatively affects the component share of the related series. Regression based on ratios show that spread ratio and ratio of number of quotations has significant and negative impact on the component share of the indicative quotes while the effect of ratio of number of quotations is significant and positive. However, when we change the sample to include open London market hours only, the ratio of number of quotations becomes insignificant. We find evidence for higher component share of indicative series in London and US and US trading hours. We do not find significant market variables in explaining the variation in the information share measure. But trading session effects are significant and imply that the information share of indicative series is higher in London and US and US trading hours. Results based on information leadership share measure shows that spreads and trading activity variables are significant. Regression based on ratios show that spread ratio and ratio of number of quotations have significant effect on the information leadership measure of the indicative quotes. We do not find evidence of significant trading session affect for the information leadership share measure.

Table A.1.1

Regression Results for the Component Share of GBP/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the component share measure of the indicative price series, and for Model 2, the dependent variable is the component share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	0.286 0.000	0.875 0.000	0.313 0.000	0.316 0.000	0.350 0.000
Indicative Spread	-0.039 0.000				
N of Indicative Quotations	-0.002 0.036				
Indicative Volatility	-0.013 0.731				
Tradeable Spread		-0.008 0.406			
N of Tradeable Quotations		0.010 0.000			
Tradeable Volatility		-0.033 0.101			
Spread Ratio			-0.067 0.021	-0.069 0.013	-0.093 0.001
Ratio of Number of Quotations			-0.001 0.456	-0.001 0.473	0.000 0.980
Volatility Ratio			-0.110 0.018	-0.112 0.014	-0.110 0.015
Trade Ratio			0.061 0.350	0.077 0.186	0.046 0.461
Only Asian Trading Session	0.012 0.457	-0.051 0.000	0.044 0.005		
Asian and London Trading Session	-0.011 0.046	0.003 0.554	-0.007 0.249		
London and US Trading Session	0.008 0.244	-0.014 0.005	0.004 0.503		
Only US Trading Session	0.016 0.112	-0.040 0.000	0.040 0.001		
London Off Hours				0.042 0.000	
Active Off Hours					0.018 0.073
Adj R-squared	0.250	0.298	0.290	0.297	0.272

Table A.1.1 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.382 0.000	0.899 0.000	0.390 0.019
Indicative Spread	-0.053 0.004		
N of Indicative Quotations	-0.005 0.007		
Indicative Volatility	-0.055 0.561		
Tradeable Spread		-0.021 0.288	
N of Tradeable Quotations		0.019 0.056	
Tradeable Volatility		-0.138 0.578	
Spread Ratio			-0.035 0.326
Ratio of Number of Quotations			0.005 0.016
Volatility Ratio			-0.244 0.055
Trade Ratio			-0.076 0.301
Asian and London Trading Session	-0.014 0.022	0.003 0.590	-0.010 0.109
London and US Trading Session	0.013 0.057	-0.025 0.027	0.005 0.395
Adj R-squared	0.217	0.168	0.247

Table A.1.2

Regression Results for the Information Share of GBP/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information share measure of the indicative price series, and for Model 2, the dependent variable is the information share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	0.343 0.000	0.837 0.000	0.287 0.000	0.291 0.000	0.330 0.000
Indicative Spread	-0.047 0.000				
N of Indicative Quotations	-0.004 0.000				
Indicative Volatility	0.016 0.633				
Tradeable Spread		0.008 0.392			
N of Tradeable Quotations		0.009 0.000			
Tradeable Volatility		-0.033 0.139			
Spread Ratio			-0.036 0.235	-0.039 0.177	-0.066 0.022
Ratio of Number of Quotations			0.001 0.662	0.001 0.655	0.001 0.239
Volatility Ratio			-0.129 0.019	-0.131 0.016	-0.129 0.016
Trade Ratio			0.025 0.726	0.040 0.528	0.005 0.944
Only Asian Trading Session	0.004 0.822	-0.061 0.000	0.051 0.004		
Asian and London Trading Session	-0.012 0.042	0.002 0.657	-0.005 0.402		
London and US Trading Session	0.011 0.112	-0.012 0.022	0.005 0.374		
Only US Trading Session	0.015 0.194	-0.048 0.000	0.046 0.000		
London Off Hours				0.048 0.000	
Active Off Hours					0.020 0.084
Adj R-squared	0.270	0.264	0.260	0.267	0.243

Table A.1.2 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.460 0.000	0.839 0.000	0.390 0.019
Indicative Spread	-0.068 0.001		
N of Indicative Quotations	-0.007 0.000		
Indicative Volatility	0.037 0.649		
Tradeable Spread		0.007 0.724	
N of Tradeable Quotations		0.020 0.081	
Tradeable Volatility		-0.242 0.394	
Spread Ratio			-0.035 0.326
Ratio of Number of Quotations			0.005 0.016
Volatility Ratio			-0.244 0.055
Trade Ratio			-0.076 0.301
Asian and London Trading Session	-0.015 0.017	0.001 0.808	-0.010 0.109
London and US Trading Session	0.016 0.017	-0.022 0.064	0.005 0.395
Adj R-squared	0.267	0.124	0.247

Table A.1.3

Regression Results for the Information Leadership Share of GBP/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information leadership share measure of the indicative price series, and for Model 2, the dependent variable is the information leadership share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	0.587 0.000	0.473 0.000	0.338 0.000	0.346 0.000	0.330 0.000
Indicative Spread	-0.029 0.004				
N of Indicative Quotations	-0.004 0.000				
Indicative Volatility	0.025 0.544				
Tradeable Spread		0.041 0.000			
N of Tradeable Quotations		0.004 0.138			
Tradeable Volatility		-0.007 0.800			
Spread Ratio			0.084 0.000	0.081 0.000	-0.066 0.022
Ratio of Number of Quotations			0.005 0.000	0.005 0.000	0.001 0.239
Volatility Ratio			-0.053 0.054	-0.054 0.050	-0.129 0.016
Trade Ratio			-0.112 0.146	-0.104 0.135	0.005 0.944
Only Asian Trading Session	0.008 0.601	-0.055 0.000	0.044 0.000		
Asian and London Trading Session	-0.005 0.370	-0.001 0.830	0.003 0.615		
London and US Trading Session	0.008 0.282	0.000 0.962	0.007 0.244		
Only US Trading Session	0.022 0.092	-0.049 0.000	0.042 0.000		
London Off Hours				0.039 0.000	
Active Off Hours					0.020 0.084
Adj R-squared	0.250 0.587	0.250 0.473	0.290 0.338	0.294 0.346	0.243 0.330

Table A.1.3 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.617 0.000	0.421 0.000	0.340 0.000
Indicative Spread	-0.039 0.019		
N of Indicative Quotations	-0.005 0.001		
Volatility	0.123 0.213		
Tradeable Spread		0.071 0.000	
N of Tradeable Quotations		0.009 0.173	
Tradeable Volatility		-0.316 0.069	
Spread Ratio			0.094 0.001
Ratio of Number of Quotations			0.005 0.009
Volatility Ratio			-0.073 0.325
Trade Ratio			-0.195 0.072
Asian and London Trading Session	-0.006 0.289	-0.004 0.465	0.001 0.889
London and US Trading Session	0.007 0.323 0.093	-0.002 0.791 0.108	0.009 0.146 0.073
Adj R-squared	0.617	0.421	0.340

Table A.2.1

Regression Results for the Component Share of MXN/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the component share measure of the indicative price series, and for Model 2, the dependent variable is the component share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.211	0.728	0.194	0.194	0.175	0.168
	0.000	0.000	0.000	0.000	0.000	0.000
Indicative Spread	0.000					
	0.029					
N of Indicative Quotations	-0.004					
	0.000					
Volatility	-0.125					
	0.004					
Tradeable Spread		0.001				
		0.026				
N of Tradeable Quotations		0.011				
		0.050				
Tradeable Volatility		-0.027				
		0.336				
Spread Ratio			-0.017	-0.008	-0.008	-0.031
			0.278	0.618	0.594	0.033
Ratio of Number of Quotations			0.000	0.001	0.000	0.001
			0.918	0.229	0.802	0.380
Volatility Ratio			-0.008	-0.009	-0.009	-0.009
			0.002	0.001	0.002	0.001
Trade Ratio			0.166	-0.254	-0.061	0.036
			0.144	0.003	0.498	0.743
Only Asian Trading Session	0.016	-0.060	0.063			
	0.252	0.010	0.000			
Asian and London Trading Session	-0.022	0.004	-0.011			
	0.020	0.749	0.266			
London and US Trading Session	-0.005	0.042	-0.055			
	0.679	0.033	0.000			
US Trading Session	-0.034	0.049	-0.051			
	0.014	0.002	0.001			
London Off Hours				0.037		
				0.000		
Active Off Hours					0.081	
					0.000	
Local Off Hours						0.068
						0.000
Adj R-squared	0.313	0.165	0.240	0.168	0.223	0.191

Table A.2.1 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.218 0.000	0.776 0.000	0.293 0.000
Indicative Spread	0.000 0.001		
N of Indicative Quotations	-0.003 0.000		
Volatility	-0.238 0.000		
Tradeable Spread		0.000 0.702	
N of Tradeable Quotations		0.011 0.089	
Tradeable Volatility		0.003 0.966	
Spread Ratio			-0.060 0.000
Ratio of Number of Quotations			0.001 0.668
Volatility Ratio			-0.045 0.000
Trade Ratio			0.206 0.061
Asian and London Trading Session	-0.023 0.014	0.012 0.366	-0.009 0.384
London and US Trading Session	0.006 0.654	0.022 0.358	-0.071 0.000
Adj R-squared	0.355	0.096	0.382

Table A.2.1 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	0.159 0.000	0.835 0.000	0.195 0.000
Indicative Spread	0.000 0.076		
N of Indicative Quotations	-0.002 0.005		
Volatility	-0.157 0.000		
Tradeable Spread		0.000 0.340	
N of Tradeable Quotations		0.013 0.049	
Tradeable Volatility		-0.135 0.112	
Spread Ratio			-0.041 0.013
Ratio of Number of Quotations			-0.001 0.544
Volatility Ratio			-0.027 0.000
Trade Ratio			0.003 0.977
Adj R-squared	0.189	0.010	0.227

Table A.2.2

Regression Results for the Information Share of USD/MXN

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information share measure of the indicative price series, and for Model 2, the dependent variable is the information share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.157	0.571	0.138	0.136	0.122	0.108
	0.000	0.000	0.000	0.000	0.000	0.000
Indicative Spread	0.000					
	0.669					
N of Indicative Quotations	-0.001					
	0.048					
Volatility	-0.086					
	0.017					
Tradeable Spread		0.001				
		0.025				
N of Tradeable Quotations		0.036				
		0.000				
Tradeable Volatility		-0.121				
		0.000				
Spread Ratio			-0.029	-0.023	-0.021	-0.036
			0.027	0.089	0.099	0.004
Ratio of Number of Quotations			0.003	0.004	0.003	0.004
			0.004	0.000	0.001	0.000
Volatility Ratio			-0.008	-0.009	-0.008	-0.008
			0.000	0.000	0.000	0.000
Trade Ratio			0.157	-0.132	-0.017	0.101
			0.117	0.080	0.834	0.308
Only Asian Trading Session	0.020	0.002	0.029			
	0.095	0.936	0.038			
Asian and London Trading Session	-0.012	-0.010	-0.010			
	0.165	0.456	0.279			
London and US Trading Session	-0.025	0.005	-0.042			
	0.030	0.843	0.000			
US Trading Session	-0.040	0.059	-0.044			
	0.001	0.002	0.001			
London Off Hours				0.016		
				0.062		
Active Off Hours					0.044	
					0.000	
Local Off Hours						0.048
						0.000
Adj R-squared	0.200	0.109	0.195	0.150	0.178	0.180

Table A.2.2 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.168	0.643	0.219
	0.000	0.000	0.000
Indicative Spread	0.000		
	0.560		
N of Indicative Quotations	-0.001		
	0.100		
Volatility	-0.169		
	0.000		
Tradeable Spread		0.000	
		0.875	
N of Tradeable Quotations		0.029	
		0.000	
Tradeable Volatility		-0.018	
		0.814	
Spread Ratio			-0.064
			0.000
Ratio of Number of Quotations			0.004
			0.013
Volatility Ratio			-0.035
			0.000
Trade Ratio			0.144
			0.179
Asian and London Trading Session	-0.013	0.002	-0.008
	0.135	0.902	0.365
London and US Trading Session	-0.016	-0.016	-0.051
	0.157	0.511	0.000
Adj R-squared	0.246	0.123	0.309

Table A.2.2 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	0.102	0.650	0.131
	0.000	0.000	0.000
Indicative Spread	0.000		
	0.806		
N of Indicative Quotations	0.000		
	0.813		
Volatility	-0.128		
	0.000		
Tradeable Spread		0.001	
		0.260	
N of Tradeable Quotations		0.010	
		0.262	
Tradeable Volatility		0.011	
		0.919	
Spread Ratio			-0.041
			0.010
Ratio of Number of Quotations			0.003
			0.061
Volatility Ratio			-0.020
			0.001
Trade Ratio			-0.012
			0.909
Adj R-squared	0.070	0.027	0.126

Table A.2.3

Regression Results for the Information Leadership Share of MXN/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information leadership share measure of the indicative price series, and for Model 2, the dependent variable is the information leadership share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.308	0.272	0.285	0.281	0.268	0.217
	0.000	0.000	0.000	0.000	0.000	0.000
Indicative Spread	-0.001					
	0.000					
N of Indicative Quotations	0.009					
	0.000					
Volatility	0.042					
	0.158					
Tradeable Spread		-0.001				
		0.026				
N of Tradeable Quotations		-0.011				
		0.050				
Tradeable Volatility		0.027				
		0.336				
Spread Ratio			-0.070	-0.068	-0.058	-0.054
			0.000	0.000	0.000	0.001
Ratio of Number of Quotations			0.014	0.014	0.014	0.012
			0.000	0.000	0.000	0.000
Volatility Ratio			-0.003	-0.003	-0.003	-0.002
			0.420	0.412	0.401	0.435
Trade Ratio			0.111	0.028	-0.026	0.270
			0.482	0.799	0.817	0.057
Only Asian Trading Session	0.076	0.060	-0.061			
	0.000	0.010	0.000			
Asian and London Trading Session	0.032	-0.004	0.004			
	0.013	0.749	0.741			
London and US Trading Session	-0.124	-0.042	-0.022			
	0.000	0.033	0.143			
US Trading Session	-0.101	-0.049	-0.058			
	0.000	0.002	0.001			
London Off Hours				-0.053		
				0.000		
Active Off Hours					-0.052	
					0.000	
Local Off Hours						0.020
						0.147
Adj R-squared	0.290	0.165	0.380	0.384	0.370	0.350

Table A.2.3 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.322 0.000	0.224 0.000	0.312 0.000
Indicative Spread	-0.001 0.000		
N of Indicative Quotations	0.007 0.000		
Volatility	-0.032 0.673		
Tradeable Spread		0.000 0.702	
N of Tradeable Quotations		-0.011 0.089	
Tradeable Volatility		-0.003 0.966	
Spread Ratio			-0.086 0.000
Ratio of Number of Quotations			0.017 0.000
Volatility Ratio			-0.006 0.433
Trade Ratio			-0.124 0.391
Asian and London Trading Session	0.026 0.049	-0.012 0.366	0.001 0.926
London and US Trading Session	-0.102 0.000	-0.022 0.358	0.001 0.961
Adj R-squared	0.328	0.096	0.399

Table A.2.3 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	0.223 0.000	0.650 0.000	0.217 0.000
Indicative Spread	0.000 0.007		
N of Indicative Quotations	0.009 0.000		
Volatility	-0.208 0.000		
Tradeable Spread		0.001 0.260	
N of Tradeable Quotations		0.010 0.262	
Tradeable Volatility		0.011 0.919	
Spread Ratio			-0.039 0.035
Ratio of Number of Quotations			0.025 0.000
Volatility Ratio			-0.013 0.049
Trade Ratio			-0.014 0.918
Adj R-squared	0.414	0.030	0.411

Table A.3.1

Regression Results for the Component Share of AUD/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the component share measure of the indicative price series, and for Model 2, the dependent variable is the component share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.064	0.968	0.054	0.061	0.071	0.086
	0.000	0.000	0.488	0.437	0.353	0.272
Indicative Spread	-0.009					
	0.083					
N of Indicative Quotations	0.000					
	0.409					
Volatility	0.002					
	0.445					
Tradeable Spread		-0.015				
		0.321				
N of Tradeable Quotations		0.001				
		0.140				
Tradeable Volatility		-0.002				
		0.330				
Spread Ratio			-0.011	-0.014	-0.020	-0.022
			0.111	0.016	0.000	0.000
Ratio of Number of Quotations			-0.001	-0.002	0.001	-0.001
			0.368	0.199	0.611	0.710
Volatility Ratio			0.015	0.015	0.007	0.009
			0.841	0.842	0.922	0.903
Trade Ratio			0.021	0.016	0.050	0.022
			0.373	0.394	0.010	0.349
Asian Trading Session	0.011	-0.015	0.012			
	0.001	0.000	0.004			
Asian and London Trading Session	-0.002	0.001	-0.001			
	0.522	0.505	0.700			
London and US Trading Session	0.001	-0.005	0.001			
	0.820	0.047	0.793			
US Trading Session	0.015	-0.020	0.015			
	0.006	0.000	0.002			
London Off Hours				0.012		
				0.000		
Active Off Hours					0.007	
					0.119	
Local Off Hours						-0.005
						0.146
Adj R-squared	0.160	0.159	0.160	0.163	0.142	0.142

Table A.3.1 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.055	0.972	0.112
	0.000	0.000	0.171
Indicative Spread	-0.005		
	0.368		
N of Indicative Quotations	0.001		
	0.416		
Volatility	-0.067		
	0.003		
Tradeable Spread		-0.018	
		0.112	
N of Tradeable Quotations		-0.001	
		0.419	
Tradeable Volatility		0.105	
		0.002	
Spread Ratio			-0.005
			0.372
Ratio of Number of Quotations			0.002
			0.256
Volatility Ratio			-0.069
			0.398
Trade Ratio			0.033
			0.119
Asian and London Trading Session	-0.002	0.002	-0.002
	0.449	0.422	0.397
London and US Trading Session	0.003	-0.005	0.004
	0.300	0.054	0.220
Adj R-squared	0.050	0.049	0.024

Table A.3.1 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	0.063	0.951	-0.101
	0.073	0.000	0.325
Indicative Spread	-0.003		
	0.870		
N of Indicative Quotations	0.001		
	0.496		
Volatility	0.001		
	0.614		
Tradeable Spread		-0.015	
		0.552	
N of Tradeable Quotations		0.001	
		0.663	
Tradeable Volatility		-0.002	
		0.462	
Spread Ratio			-0.006
			0.633
Ratio of Number of Quotations			-0.003
			0.168
Volatility Ratio			0.198
			0.051
Trade Ratio			-0.031
			0.369
Adj R-squared	0.000	0.000	0.023

Table A.3.2

Regression Results for the Information Share of AUD/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information share measure of the indicative price series, and for Model 2, the dependent variable is the information share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.039	0.977	0.037	0.025	0.051	0.062
	0.001	0.000	0.618	0.739	0.482	0.402
Indicative Spread	-0.003					
	0.622					
N of Indicative Quotations	0.001					
	0.006					
Volatility	0.002					
	0.250					
Tradeable Spread		-0.016				
		0.297				
N of Tradeable Quotations		-0.001				
		0.281				
Tradeable Volatility		-0.003				
		0.224				
Spread Ratio			-0.014	-0.010	-0.023	-0.020
			0.044	0.071	0.000	0.000
Ratio of Number of Quotations			-0.005	-0.004	-0.001	-0.004
			0.003	0.001	0.209	0.011
Volatility Ratio			0.049	0.050	0.039	0.045
			0.487	0.486	0.585	0.526
Trade Ratio			0.006	0.016	0.046	0.004
			0.803	0.423	0.030	0.862
Only Asian Trading Session	0.014	-0.016	0.016			
	0.000	0.000	0.000			
Asian and London Trading Session	-0.003	0.001	0.001			
	0.155	0.507	0.498			
London and US Trading Session	-0.001	-0.001	-0.002			
	0.706	0.647	0.550			
US Trading Session	0.015	-0.015	0.010			
	0.004	0.000	0.051			
London Off Hours				0.016		
				0.000		
Active Off Hours					0.000	
					0.922	
Local Off Hours						-0.012
						0.001
Adj R-squared	0.152	0.145	0.159	0.157	0.111	0.148

Table A.3.2 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.035	0.988	0.103
	0.011	0.000	0.175
Indicative Spread	0.002		
	0.754		
N of Indicative Quotations	0.001		
	0.121		
Volatility	-0.061		
	0.015		
Tradeable Spread		-0.026	
		0.042	
N of Tradeable Quotations		-0.004	
		0.000	
Tradeable Volatility		0.159	
		0.000	
Spread Ratio			-0.007
			0.233
Ratio of Number of Quotations			-0.003
			0.082
Volatility Ratio			-0.036
			0.626
Trade Ratio			0.013
			0.577
Asian and London Trading Session	-0.003	0.002	0.000
	0.291	0.388	0.900
London and US Trading Session	0.002	0.000	0.000
	0.429	0.887	0.882
Adj R-squared	0.012	0.055	0.015

Table A.3.2 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	0.034	0.957	-0.071
	0.337	0.000	0.491
Indicative Spread	0.006		
	0.699		
N of Indicative Quotations	0.002		
	0.069		
Volatility	0.002		
	0.403		
Tradeable Spread		-0.014	
		0.539	
N of Tradeable Quotations		-0.001	
		0.479	
Tradeable Volatility		-0.002	
		0.275	
Spread Ratio			-0.016
			0.225
Ratio of Number of Quotations			-0.006
			0.010
Volatility Ratio			0.190
			0.062
Trade Ratio			-0.021
			0.607
Adj R-squared	0.060	0.019	0.080

Table A.3.3

Regression Results for the Information Leadership Share of AUD/USD

This table presents regression results where, for Models 1, 3, 4, and 5, the dependent variable is the information leadership share measure of the indicative price series, and for Model 2, the dependent variable is the information leadership share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.330	0.633	0.274	0.212	0.271	0.256
	0.000	0.000	0.024	0.089	0.024	0.031
Indicative Spread	0.024					
	0.004					
N of Indicative Quotations	0.002					
	0.003					
Volatility	0.004					
	0.094					
Tradeable Spread		-0.021				
		0.266				
N of Tradeable Quotations		-0.005				
		0.000				
Tradeable Volatility		-0.002				
		0.232				
Spread Ratio			-0.005	0.017	-0.007	0.014
			0.603	0.020	0.282	0.020
Ratio of Number of Quotations			-0.007	-0.004	-0.002	-0.007
			0.003	0.067	0.214	0.003
Volatility Ratio			0.175	0.174	0.161	0.179
			0.136	0.152	0.169	0.123
Trade Ratio			-0.075	-0.021	-0.034	-0.084
			0.097	0.623	0.413	0.056
Only Asian Trading Session	0.012	-0.006	0.014			
	0.014	0.131	0.012			
Asian and London Trading Session	-0.007	0.001	0.004			
	0.169	0.846	0.309			
London and US Trading Session	-0.007	0.014	-0.010			
	0.135	0.002	0.035			
US Trading Session	-0.001	0.019	-0.021			
	0.936	0.001	0.010			
London Off Hours				0.013		
				0.006		
Active Off Hours					-0.025	
					0.000	
Local Off Hours						-0.026
						0.000
Adj R-squared	0.080	0.100	0.070	0.021	0.045	0.065

Table A.3.3 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.344 0.000	0.675 0.000	0.383 0.010
Indicative Spread	0.021 0.049		
N of Indicative Quotations	0.001 0.437		
Volatility	0.029 0.685		
Tradeable Spread		-0.055 0.071	
N of Tradeable Quotations		-0.010 0.000	
Tradeable Volatility		0.243 0.008	
Spread Ratio			-0.011 0.329
Ratio of Number of Quotations			-0.018 0.000
Volatility Ratio			0.111 0.433
Trade Ratio			-0.073 0.137
Asian and London Trading Session	-0.004 0.458	0.002 0.591	0.005 0.262
London and US Trading Session	-0.006 0.270	0.018 0.001	-0.015 0.006
Adj R-squared	0.023	0.079	0.069

Table A.3.3 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	0.328	0.617	0.309
	0.000	0.000	0.166
Indicative Spread	0.032		
	0.109		
N of Indicative Quotations	0.002		
	0.004		
Volatility	0.003		
	0.169		
Tradeable Spread		-0.014	
		0.743	
N of Tradeable Quotations		-0.004	
		0.202	
Tradeable Volatility		-0.003	
		0.185	
Spread Ratio			-0.012
			0.626
Ratio of Number of Quotations			-0.004
			0.243
Volatility Ratio			0.138
			0.521
Trade Ratio			-0.014
			0.875
Adj R-squared	0.039	0.036	0.001

Table A.4.1

Regression Results for the Component Share of USD/CAD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the component share measure of the indicative price series, and for Model 2, the dependent variable is the component share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.156 0.002	0.953 0.000	0.116 0.000	0.116 0.000	0.093 0.000	0.115 0.000
Indicative Spread	-0.031 0.011					
N of Indicative Quotations	-0.002 0.013					
Volatility	0.222 0.178					
Tradeable Spread		0.003 0.832				
N of Tradeable Quotations		0.011 0.101				
Tradeable Volatility		-0.562 0.101				
Spread Ratio			-0.029 0.052	-0.026 0.067	-0.013 0.177	-0.039 0.001
Ratio of Number of Quotations			0.001 0.599	0.001 0.293	0.001 0.316	0.000 0.666
Volatility Ratio			-0.019 0.000	-0.019 0.000	-0.020 0.000	-0.019 0.000
Trade Ratio			0.018 0.514	-0.067 0.006	-0.039 0.043	0.024 0.348
Only Asian Trading Session	-0.016 0.113	-0.019 0.003	0.011 0.168			
Asian and London Trading Session	0.004 0.240	-0.008 0.037	-0.001 0.753			
London and US Trading Session	-0.003 0.546	0.000 0.999	-0.013 0.000			
US Trading Session	-0.025 0.010	0.004 0.151	-0.016 0.008			
London Off Hours				0.004 0.490		
Active Off Hours					0.020 0.002	
Local Off Hours						0.018 0.000
Adj R-squared	0.241	0.229	0.379	0.345	0.370	0.375

Table A.4.1 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.025	0.989	0.082
	0.281	0.000	0.001
Indicative Spread	0.001		
	0.781		
N of Indicative Quotations	-0.001		
	0.358		
Volatility	-0.061		
	0.265		
Tradeable Spread		-0.003	
		0.685	
N of Tradeable Quotations		-0.001	
		0.797	
Tradeable Volatility		-0.084	
		0.428	
Spread Ratio			-0.013
			0.283
Ratio of Number of Quotations			-0.001
			0.237
Volatility Ratio			-0.015
			0.000
Trade Ratio			0.022
			0.324
Asian and London Trading Session	0.007	-0.006	0.002
	0.036	0.075	0.528
London and US Trading Session	0.003	0.004	-0.013
	0.258	0.296	0.001
Adj R-squared	0.071	0.075	0.331

Table A.4.1 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	-0.019 0.000	1.003 0.000	0.004 0.619
Indicative Spread	0.008 0.000		
N of Indicative Quotations	0.000 0.494		
Volatility	-0.001 0.962		
Tradeable Spread		-0.003 0.513	
N of Tradeable Quotations		0.003 0.439	
Tradeable Volatility		-0.286 0.222	
Spread Ratio			0.009 0.094
Ratio of Number of Quotations			0.001 0.143
Volatility Ratio			-0.006 0.007
Trade Ratio			-0.009 0.462
Adj R-squared	0.130	0.200	0.166

Table A.4.2

Regression Results for the Information Share of USD/CAD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information share measure of the indicative price series, and for Model 2, the dependent variable is the information share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.147	0.952	0.106	0.108	0.087	0.113
	0.004	0.000	0.000	0.000	0.000	0.000
Indicative Spread	-0.029					
	0.023					
N of Indicative Quotations	-0.002					
	0.025					
Volatility	0.214					
	0.227					
Tradeable Spread		0.001				
		0.926				
N of Tradeable Quotations		0.016				
		0.093				
Tradeable Volatility		-0.748				
		0.089				
Spread Ratio			-0.018	-0.016	-0.005	-0.034
			0.317	0.319	0.635	0.002
Ratio of Number of Quotations			0.001	0.002	0.002	0.001
			0.351	0.202	0.202	0.388
Volatility Ratio			-0.022	-0.022	-0.023	-0.022
			0.002	0.002	0.001	0.001
Trade Ratio			0.003	-0.082	-0.048	0.012
			0.947	0.026	0.073	0.731
Only Asian Trading Session	-0.015	-0.018	0.015			
	0.132	0.006	0.162			
Asian and London Trading Session	0.004	-0.009	-0.001			
	0.208	0.026	0.808			
London and US Trading Session	-0.003	-0.002	-0.012			
	0.568	0.756	0.001			
US Trading Session	-0.024	0.005	-0.013			
	0.013	0.099	0.059			
London Off Hours				0.006		
				0.375		
Active Off Hours					0.023	
					0.006	
Local Off Hours						0.018
						0.000
Adj R-squared	0.216	0.191	0.289	0.266	0.287	0.286

Table A.4.2 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.015	0.984	0.077
	0.478	0.000	0.004
Indicative Spread	0.004		
	0.416		
N of Indicative Quotations	0.000		
	0.641		
Volatility	-0.082		
	0.153		
Tradeable Spread		-0.001	
		0.883	
N of Tradeable Quotations		-0.001	
		0.854	
Tradeable Volatility		-0.122	
		0.275	
Spread Ratio			-0.009
			0.536
Ratio of Number of Quotations			-0.001
			0.362
Volatility Ratio			-0.016
			0.000
Trade Ratio			0.024
			0.276
Asian and London Trading Session	0.007	-0.006	0.002
	0.032	0.080	0.457
London and US Trading Session	0.003	0.004	-0.013
	0.287	0.237	0.001
Adj R-squared	0.058	0.072	0.313

Table A.4.2 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	-0.024 0.000	1.001 0.000	0.001 0.959
Indicative Spread	0.009 0.000		
N of Indicative Quotations	0.000 0.287		
Volatility	-0.010 0.759		
Tradeable Spread		-0.002 0.759	
N of Tradeable Quotations		0.004 0.483	
Tradeable Volatility		-0.354 0.278	
Spread Ratio			0.013 0.083
Ratio of Number of Quotations			0.001 0.076
Volatility Ratio			-0.007 0.013
Trade Ratio			-0.006 0.684
Adj R-squared	0.110	0.189	0.155

Table A.4.3

Regression Results for the Information Leadership Share of CAD/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information leadership share measure of the indicative price series, and for Model 2, the dependent variable is the information leadership share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.393	0.624	0.405	0.406	0.379	0.372
	0.000	0.000	0.000	0.000	0.000	0.000
Indicative Spread	0.010					
	0.452					
N of Indicative Quotations	0.002					
	0.165					
Volatility	-0.196					
	0.198					
Tradeable Spread		-0.029				
		0.254				
N of Tradeable Quotations		0.009				
		0.382				
Tradeable Volatility		-0.316				
		0.440				
Spread Ratio			0.023	0.025	0.045	0.046
			0.486	0.415	0.074	0.010
Ratio of Number of Quotations			0.005	0.005	0.005	0.005
			0.018	0.011	0.008	0.015
Volatility Ratio			-0.014	-0.014	-0.016	-0.016
			0.079	0.078	0.042	0.036
Trade Ratio			-0.045	-0.074	-0.087	-0.056
			0.602	0.197	0.125	0.500
Only Asian Trading Session	-0.005	0.014	-0.012			
	0.757	0.171	0.523			
Asian and London Trading Session	0.005	-0.007	0.005			
	0.580	0.434	0.562			
London and US Trading Session	-0.007	0.001	-0.003			
	0.382	0.936	0.752			
US Trading Session	-0.016	0.021	-0.017			
	0.282	0.045	0.306			
London Off Hours				-0.014		
				0.240		
Active Off Hours					-0.003	
					0.805	
Local Off Hours						0.005
						0.580
Adj R-squared	0.040	0.050	0.065	0.071	0.067	0.068

Table A.4.3 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.333 0.000	0.625 0.000	0.400 0.000
Indicative Spread	0.023 0.100		
N of Indicative Quotations	0.003 0.059		
Volatility	-0.333 0.168		
Tradeable Spread		-0.024 0.364	
N of Tradeable Quotations		0.001 0.922	
Tradeable Volatility		-0.079 0.814	
Spread Ratio			0.026 0.487
Ratio of Number of Quotations			0.005 0.137
Volatility Ratio			-0.016 0.151
Trade Ratio			-0.056 0.605
Asian and London Trading Session	0.005 0.544	-0.006 0.595	0.005 0.566
London and US Trading Session	-0.007 0.458	0.005 0.628	-0.003 0.811
Adj R-squared	0.044		0.038

Table A.4.3 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	0.310 0.000	0.669 0.000	0.347 0.000
Indicative Spread	0.023 0.058		
N of Indicative Quotations	0.004 0.009		
Volatility	-0.350 0.147		
Tradeable Spread		-0.033 0.342	
N of Tradeable Quotations		-0.004 0.820	
Tradeable Volatility		-0.041 0.959	
Spread Ratio			0.054 0.053
Ratio of Number of Quotations			0.006 0.000
Volatility Ratio			-0.021 0.085
Trade Ratio			-0.036 0.729
Adj R-squared	0.021	0.001	0.053

Table A.5.1

Regression Results for the Component Share of NZD/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the component share measure of the indicative price series, and for Model 2, the dependent variable is the component share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.063	0.063	0.138	0.027	0.086	0.110
	0.176	0.158	0.000	0.488	0.069	0.011
Indicative Spread	0.010	0.016		0.026	0.019	0.010
	0.513	0.298		0.059	0.237	0.478
N of Indicative Quotations	0.000	-0.001		0.001	-0.010	-0.005
	0.925	0.725		0.772	0.000	0.010
Volatility	-0.022	-0.023		-0.013	0.017	-0.012
	0.448	0.441		0.608	0.305	0.593
Tradeable Spread		-0.009		-0.011	-0.004	-0.001
		0.317		0.167	0.648	0.948
N of Tradeable Quotations		0.003		-0.003	0.012	0.006
		0.609		0.548	0.008	0.147
Tradeable Volatility			0.009			
			0.292			
Spread Ratio			-0.004			
			0.003			
Ratio of Number of Quotations			-0.029			
			0.026			
Volatility Ratio			-0.009			
			0.727			
Trade Ratio	0.034	0.034	0.033			
	0.000	0.000	0.000			
Only Asian Trading Session	0.002	0.002	0.003			
	0.648	0.672	0.458			
Asian and London Trading Session	-0.008	-0.009	-0.015			
	0.110	0.088	0.002			
London and US Trading Session	0.022	0.024	0.022			
	0.003	0.002	0.001			
US Trading Session				0.038		
				0.000		
London Off Hours					-0.005	
					0.419	
Active Off Hours						-0.025
						0.000
Local Off Hours						
Adj R-squared	0.196	0.198	0.260	0.191	0.1089	0.1682

Table A.5.1 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.152	0.175	0.151
	0.002	0.000	0.000
Indicative Spread	-0.021	-0.024	
	0.152	0.100	
N of Indicative Quotations	0.004	0.000	
	0.103	0.977	
Volatility	-0.192	-0.304	
	0.029	0.005	
Tradeable Spread		-0.002	
		0.807	
N of Tradeable Quotations		0.017	
		0.019	
Tradeable Volatility			0.010
			0.276
Spread Ratio			-0.001
			0.653
Ratio of Number of Quotations			-0.061
			0.000
Volatility Ratio			0.027
			0.422
Trade Ratio	0.004	0.005	0.003
	0.438	0.284	0.437
Asian and London Trading Session	-0.007	-0.012	-0.012
	0.146	0.023	0.019
London and US Trading Session			
Adj R-squared	0.120	0.142	0.214

Table A.5.1 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	-0.096	-0.052	0.155
	0.247	0.562	0.000
Indicative Spread	0.077	0.071	
	0.009	0.029	
N of Indicative Quotations	-0.002	0.005	
	0.630	0.699	
Volatility	0.015	0.028	
	0.477	0.419	
Tradeable Spread		-0.021	
		0.321	
N of Tradeable Quotations		-0.012	
		0.581	
Tradeable Volatility			0.046
			0.052
Spread Ratio			-0.008
			0.011
Ratio of Number of Quotations			-0.038
			0.281
Volatility Ratio			-0.065
			0.172
Trade Ratio			
Adj R-squared	0.026	0.019	0.100

Table A.5.2

Regression Results for the Information Share of NZD/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information share measure of the indicative price series, and for Model 2, the dependent variable is the information share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.043	0.896	0.108	0.093	0.145	0.215
	0.299	0.000	0.000	0.002	0.000	0.000
Indicative Spread	0.013					
	0.346					
N of Indicative Quotations	0.000					
	0.911					
Volatility	-0.037					
	0.150					
Tradeable Spread		0.013				
		0.020				
N of Tradeable Quotations		0.001				
		0.845				
Tradeable Volatility		-0.028				
		0.007				
Spread Ratio			0.009	0.018	-0.012	-0.012
			0.298	0.053	0.150	0.144
Ratio of Number of Quotations			-0.002	0.000	0.000	-0.003
			0.320	0.834	0.873	0.016
Volatility Ratio			-0.029	-0.047	-0.040	-0.035
			0.052	0.044	0.090	0.048
Trade Ratio			0.029	0.038	0.093	-0.007
			0.274	0.127	0.001	0.794
Only Asian Trading Session	0.032	-0.033	0.030			
	0.000	0.000	0.000			
Asian and London Trading Session	0.001	-0.003	0.002			
	0.843	0.479	0.578			
London and US Trading Session	-0.010	0.010	-0.014			
	0.037	0.049	0.006			
US Trading Session	0.014	-0.016	0.018			
	0.044	0.012	0.014			
London Off Hours				0.039		
				0.000		
Active Off Hours					0.008	
					0.253	
Local Off Hours						-0.037
						0.000
Adj R-squared	0.168	0.135	0.208	0.162	0.047	0.176

Table A.5.2 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.073	0.909	0.145
	0.181	0.000	0.000
Indicative Spread	0.001		
	0.970		
N of Indicative Quotations	0.004		
	0.101		
Volatility	-0.228		
	0.006		
Tradeable Spread		0.004	
		0.666	
N of Tradeable Quotations		0.014	
		0.331	
Tradeable Volatility		-0.221	
		0.424	
Spread Ratio			-0.003
			0.749
Ratio of Number of Quotations			0.002
			0.304
Volatility Ratio			-0.064
			0.002
Trade Ratio			0.069
			0.047
Asian and London Trading Session	0.000	-0.005	0.003
	0.967	0.332	0.459
London and US Trading Session	-0.009	0.006	-0.010
	0.051	0.346	0.053
Adj R-squared	0.088	0.079	0.200

Table A.5.2 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	-0.110	0.854	0.124
	0.202	0.000	0.003
Indicative Spread	0.076		
	0.012		
N of Indicative Quotations	-0.001		
	0.782		
Volatility	-0.001		
	0.972		
Tradeable Spread		0.016	
		0.506	
N of Tradeable Quotations		-0.003	
		0.739	
Tradeable Volatility		-0.023	
		0.022	
Spread Ratio			0.047
			0.081
Ratio of Number of Quotations			-0.005
			0.123
Volatility Ratio			-0.044
			0.283
Trade Ratio			-0.030
			0.546
Adj R-squared	0.016	0.006	0.073

Table A.5.3

Regression Results for the Information Leadership Share of NZD/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information leadership share measure of the indicative price series, and for Model 2, the dependent variable is the information leadership share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.423	0.555	0.327	0.308	0.341	0.215
	0.000	0.000	0.000	0.000	0.000	0.000
Indicative Spread	-0.006					
	0.811					
N of Indicative Quotations	-0.001					
	0.634					
Volatility	-0.063					
	0.002					
Tradeable Spread		0.027				
		0.027				
N of Tradeable Quotations		0.006				
		0.169				
Tradeable Volatility		-0.010				
		0.155				
Spread Ratio			0.005	0.013	-0.005	-0.012
			0.807	0.545	0.796	0.144
Ratio of Number of Quotations			0.006	0.008	0.008	-0.003
			0.216	0.096	0.119	0.016
Volatility Ratio			-0.005	-0.015	-0.011	-0.035
			0.734	0.389	0.559	0.048
Trade Ratio			0.164	0.176	0.196	-0.007
			0.001	0.000	0.000	0.794
Only Asian Trading Session	0.011	-0.014	0.013			
	0.190	0.092	0.079			
Asian and London Trading Session	0.006	-0.005	0.003			
	0.500	0.491	0.636			
London and US Trading Session	-0.016	0.016	-0.010			
	0.040	0.041	0.297			
US Trading Session	-0.021	0.007	-0.001			
	0.133	0.608	0.933			
London Off Hours				0.016		
				0.012		
Active Off Hours					-0.005	
					0.663	
Local Off Hours						-0.037
						0.000
Adj R-squared	0.037	0.054	0.068	0.064	0.051	0.176

Table A.5.3 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.187	0.659	0.416
	0.183	0.000	0.000
Indicative Spread	0.066		
	0.141		
N of Indicative Quotations	0.000		
	0.999		
Volatility	-0.260		
	0.093		
Tradeable Spread		-0.034	
		0.144	
N of Tradeable Quotations		0.020	
		0.117	
Tradeable Volatility		-0.130	
		0.600	
Spread Ratio			-0.046
			0.040
Ratio of Number of Quotations			0.013
			0.004
Volatility Ratio			-0.040
			0.032
Trade Ratio			0.228
			0.001
Asian and London Trading Session	-0.005	-0.006	0.006
	0.633	0.462	0.380
London and US Trading Session	-0.017	0.008	-0.002
	0.041	0.355	0.844
Adj R-squared	0.055	0.056	0.112

Table A.5.3 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	0.413	0.532	0.345
	0.001	0.000	0.000
Indicative Spread	0.000		
	0.997		
N of Indicative Quotations	0.000		
	0.931		
Volatility	-0.048		
	0.026		
Tradeable Spread		0.032	
		0.241	
N of Tradeable Quotations		0.003	
		0.631	
Tradeable Volatility		-0.006	
		0.492	
Spread Ratio			0.007
			0.793
Ratio of Number of Quotations			0.010
			0.010
Volatility Ratio			-0.023
			0.348
Trade Ratio			0.146
			0.018
Adj R-squared	0.000	0.000	0.014

Table A.6.1

Regression Results for the Component Share of USD/SGD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the component share measure of the indicative price series, and for Model 2, the dependent variable is the component share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.095	0.904	0.379	0.439	0.454	0.496
	0.116	0.000	0.000	0.000	0.000	0.000
Indicative Spread	0.016					
	0.192					
N of Indicative Quotations	-0.007					
	0.129					
Volatility	0.461					
	0.029					
Tradeable Spread		-0.004				
		0.001				
N of Tradeable Quotations		-0.023				
		0.014				
Tradeable Volatility		0.000				
		0.851				
Spread Ratio			-0.081	-0.091	-0.089	-0.098
			0.001	0.000	0.000	0.000
Ratio of Number of Quotations			-0.023	-0.030	-0.032	-0.028
			0.000	0.000	0.000	0.000
Volatility Ratio			-0.029	-0.043	-0.046	-0.034
			0.019	0.021	0.039	0.029
Trade Ratio			-0.043	0.025	0.063	-0.044
			0.143	0.484	0.112	0.324
Only Asian Trading Session	0.031	-0.039	0.052			
	0.008	0.000	0.000			
Asian and London Trading Session	0.005	-0.005	0.034			
	0.709	0.626	0.038			
London and US Trading Session	0.012	-0.008	0.002			
	0.096	0.162	0.828			
US Trading Session	0.044	-0.060	0.045			
	0.001	0.000	0.000			
London Off Hours				0.051		
				0.000		
Active Off Hours					0.042	
					0.016	
Local Off Hours						-0.044
						0.002
Adj R-squared	0.053	0.470	0.414	0.413	0.378	0.390

Table A.6.1 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.126	0.901	0.373
	0.134	0.000	0.001
Indicative Spread	0.010		
	0.536		
N of Indicative Quotations	-0.016		
	0.059		
Volatility	1.036		
	0.207		
Tradeable Spread		-0.004	
		0.063	
N of Tradeable Quotations		-0.002	
		0.864	
Tradeable Volatility		-0.169	
		0.133	
Spread Ratio			-0.067
			0.058
Ratio of Number of Quotations			-0.020
			0.017
Volatility Ratio			-0.052
			0.014
Trade Ratio			-0.029
			0.507
Asian and London Trading Session	0.010	-0.011	0.028
	0.497	0.213	0.127
London and US Trading Session	0.012	-0.014	0.002
	0.068	0.015	0.790
Adj R-squared	0.005	0.508	0.338

Table A.6.1 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	0.185	0.815	0.594
	0.325	0.000	0.000
Indicative Spread	0.021		
	0.537		
N of Indicative Quotations	-0.021		
	0.002		
Volatility	0.554		
	0.078		
Tradeable Spread		-0.005	
		0.003	
N of Tradeable Quotations		-0.012	
		0.213	
Tradeable Volatility		0.000	
		0.494	
Spread Ratio			-0.117
			0.003
Ratio of Number of Quotations			-0.045
			0.000
Volatility Ratio			-0.031
			0.059
Trade Ratio			-0.032
			0.665
Adj R-squared	0.088	0.458	0.462

Table A.6.2

Regression Results for the Information Share of USD/SGD

This table presents regression results where, for Models 1, 3, 4, and 5, the dependent variable is the information share measure of the indicative price series, and for Model 2, the dependent variable is the information share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.001	0.888	0.272	0.339	0.356	0.398
	0.985	0.000	0.000	0.000	0.000	0.000
Indicative Spread	0.038					
	0.000					
N of Indicative Quotations	-0.003					
	0.466					
Volatility	-0.084					
	0.590					
Tradeable Spread		-0.002				
		0.138				
N of Tradeable Quotations		-0.014				
		0.169				
Tradeable Volatility		0.000				
		0.121				
Spread Ratio			-0.042	-0.055	-0.054	-0.063
			0.098	0.031	0.045	0.021
Ratio of Number of Quotations			-0.010	-0.017	-0.019	-0.015
			0.076	0.019	0.010	0.014
Volatility Ratio			-0.027	-0.041	-0.044	-0.032
			0.051	0.037	0.065	0.057
Trade Ratio			-0.034	0.030	0.067	-0.039
			0.315	0.443	0.125	0.443
Only Asian Trading Session	0.027	-0.043	0.053			
	0.027	0.000	0.000			
Asian and London Trading Session	-0.004	-0.004	0.023			
	0.784	0.735	0.240			
London and US Trading Session	0.004	-0.006	0.002			
	0.671	0.502	0.825			
US Trading Session	0.037	-0.050	0.042			
	0.007	0.000	0.002			
London Off Hours				0.055		
				0.000		
Active Off Hours					0.040	
					0.041	
Local Off Hours						-0.044
						0.009
Adj R-squared	0.086	0.285	0.210	0.255	0.207	0.221

Table A.6.2 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.007	0.885	0.265
	0.926	0.000	0.010
Indicative Spread	0.039		
	0.005		
N of Indicative Quotations	-0.011		
	0.129		
Volatility	0.050		
	0.944		
Tradeable Spread		-0.001	
		0.669	
N of Tradeable Quotations		0.008	
		0.459	
Tradeable Volatility		-0.224	
		0.002	
Spread Ratio			-0.032
			0.355
Ratio of Number of Quotations			-0.008
			0.315
Volatility Ratio			-0.046
			0.008
Trade Ratio			-0.019
			0.704
Asian and London Trading Session	0.000	-0.010	0.018
	0.987	0.252	0.423
London and US Trading Session	0.005	-0.012	0.002
	0.565	0.059	0.797
Adj R-squared	0.018	0.393	0.144

Table A.6.2 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	0.045	0.792	0.502
	0.808	0.000	0.001
Indicative Spread	0.055		
	0.107		
N of Indicative Quotations	-0.016		
	0.024		
Volatility	0.073		
	0.800		
Tradeable Spread		-0.003	
		0.114	
N of Tradeable Quotations		-0.005	
		0.692	
Tradeable Volatility		0.000	
		0.827	
Spread Ratio			-0.073
			0.136
Ratio of Number of Quotations			-0.034
			0.020
Volatility Ratio			-0.031
			0.095
Trade Ratio			-0.049
			0.540
Adj R-squared	0.111	0.304	0.296

Table A.6.3

Regression Results for the Information Leadership Share of USD/SGD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information leadership share measure of the indicative price series, and for Model 2, the dependent variable is the information leadership share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.183 0.019	0.525 0.000	0.193 0.000	0.233 0.000	0.243 0.000	0.258 0.000
Indicative Spread	0.066 0.000					
N of Indicative Quotations	0.002 0.852					
Volatility	-1.368 0.000					
Tradeable Spread		0.004 0.000				
N of Tradeable Quotations		0.033 0.000				
Tradeable Volatility		0.000 0.000				
Spread Ratio			0.073 0.000	0.065 0.000	0.066 0.000	0.063 0.001
Ratio of Number of Quotations			0.037 0.000	0.034 0.000	0.033 0.000	0.035 0.000
Volatility Ratio			-0.003 0.716	-0.008 0.431	-0.008 0.472	-0.004 0.667
Trade Ratio			0.046 0.239	0.051 0.172	0.062 0.114	0.027 0.545
Only Asian Trading Session	-0.001 0.923	-0.027 0.009	0.026 0.018			
Asian and London Trading Session	-0.004 0.777	-0.020 0.093	-0.003 0.818			
London and US Trading Session	-0.011 0.342	-0.004 0.724	0.011 0.331			
US Trading Session	0.002 0.922	-0.002 0.911	0.026 0.090			
London Off Hours				0.027 0.001		
Active Off Hours					0.011 0.368	
Local Off Hours						-0.016 0.121
Adj R-squared	0.070	0.347	0.341	0.279	0.262	0.266

Table A.6.3 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.072	0.525	0.171
	0.409	0.000	0.000
Indicative Spread	0.094		
	0.000		
N of Indicative Quotations	0.004		
	0.660		
Volatility	-2.901		
	0.000		
Tradeable Spread		0.006	
		0.000	
N of Tradeable Quotations		0.037	
		0.006	
Tradeable Volatility		-0.092	
		0.288	
Spread Ratio			0.070
			0.000
Ratio of Number of Quotations			0.038
			0.000
Volatility Ratio			0.007
			0.635
Trade Ratio			0.036
			0.474
Asian and London Trading Session	-0.010	-0.019	0.000
	0.537	0.106	1.000
London and US Trading Session	-0.010	-0.005	0.012
	0.384	0.667	0.314
Adj R-squared	0.079	0.390	0.301

Table A.6.3 (cont'd)

Panel C – Local Market Open	Model 1	Model 2	Model 3
Constant	0.138	0.487	0.314
	0.224	0.000	0.000
Indicative Spread	0.080		
	0.002		
N of Indicative Quotations	0.005		
	0.551		
Volatility	-1.107		
	0.000		
Tradeable Spread		0.003	
		0.095	
N of Tradeable Quotations		0.025	
		0.092	
Tradeable Volatility		0.000	
		0.141	
Spread Ratio			0.072
			0.008
Ratio of Number of Quotations			0.021
			0.028
Volatility Ratio			-0.011
			0.256
Trade Ratio			-0.011
			0.841
Adj R-squared	0.087	0.188	0.173

Table A.7.1

Regression Results for the Component Share of USD/ZAR

This table presents regression results where, for Models 1, 3, 4, and 5, the dependent variable is the component share measure of the indicative price series, and for Model 2, the dependent variable is the component share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.484	0.502	0.696	0.606	0.484	0.502
	0.000	0.000	0.000	0.000	0.000	0.000
Indicative Spread	-0.001				-0.001	
	0.035				0.035	
N of Indicative Quotations	0.002				0.002	
	0.524				0.524	
Volatility	-0.087				-0.087	
	0.152				0.152	
Tradeable Spread		0.000				0.000
		0.614				0.614
N of Tradeable Quotations		0.002				0.002
		0.851				0.851
Tradeable Volatility		-0.017				-0.017
		0.850				0.850
Spread Ratio			-0.078	-0.056		
			0.272	0.437		
Ratio of Number of Quotations			0.000	0.000		
			0.139	0.042		
Volatility Ratio			-0.169	-0.170		
			0.000	0.000		
Trade Ratio			0.094	0.167		
			0.544	0.258		
Only Asian Trading Session	-0.134	0.185	-0.174		-0.134	0.185
	0.018	0.000	0.000		0.018	0.000
Asian and London Trading Session	-0.045	0.060	-0.056		-0.045	0.060
	0.004	0.000	0.001		0.004	0.000
London and US Trading Session	-0.094	0.102	-0.102		-0.094	0.102
	0.000	0.000	0.000		0.000	0.000
US Trading Session	-0.116	0.134	-0.129		-0.116	0.134
	0.003	0.000	0.000		0.003	0.000
London Off Hours				-0.079		
				0.000		
Active Off Hours						
Local Off Hours						
Adj R-squared						

Table A.7.1 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.546 0.000	0.369 0.000	0.760 0.000
Indicative Spread	-0.001 0.015		
N of Indicative Quotations	0.002 0.624		
Volatility	-0.284 0.001		
Tradeable Spread		0.001 0.039	
N of Tradeable Quotations		0.075 0.001	
Tradeable Volatility		0.070 0.485	
Spread Ratio			-0.059 0.466
Ratio of Number of Quotations			0.004 0.000
Volatility Ratio			-0.401 0.000
Trade Ratio			0.147 0.293
Asian and London Trading Session	-0.031 0.067	0.046 0.008	-0.041 0.049
London and US Trading Session	-0.091 0.000	0.095 0.000	-0.100 0.000
Adj R-squared	0.246	0.226	0.286

Table A.7.2

Regression Results for the Information Share of USD/ZAR

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information share measure of the indicative price series, and for Model 2, the dependent variable is the information share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.536	0.465	0.612	0.536	0.536	0.465
	0.000	0.000	0.000	0.000	0.000	0.000
Indicative Spread	-0.001				-0.001	
	0.065				0.065	
N of Indicative Quotations	0.001				0.001	
	0.859				0.859	
Volatility	-0.149				-0.149	
	0.042				0.042	
Tradeable Spread		0.000				0.000
		0.161				0.161
N of Tradeable Quotations		0.026				0.026
		0.043				0.043
Tradeable Volatility		-0.011				-0.011
		0.911				0.911
Spread Ratio			0.027	0.036		
			0.763	0.687		
Ratio of Number of Quotations			0.000	0.000		
			0.866	0.993		
Volatility Ratio			-0.162	-0.162		
			0.000	0.000		
Trade Ratio			0.084	0.124		
			0.661	0.487		
Only Asian Trading Session	-0.107	0.125	-0.129		-0.107	0.125
	0.103	0.003	0.000		0.103	0.003
Asian and London Trading Session	-0.042	0.053	-0.054		-0.042	0.053
	0.023	0.004	0.005		0.023	0.004
London and US Trading Session	-0.093	0.095	-0.097		-0.093	0.095
	0.000	0.000	0.000		0.000	0.000
US Trading Session	-0.117	0.121	-0.112		-0.117	0.121
	0.011	0.000	0.000		0.011	0.000
London Off Hours				-0.053		
				0.039		
Active Off Hours						
Local Off Hours						
Adj R-squared	0.122	0.104	0.159	0.135	0.122	0.104

Table A.7.2 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.645 0.000	0.341 0.000	0.653 0.000
Indicative Spread	-0.001 0.064		
N of Indicative Quotations	-0.002 0.657		
Volatility	-0.328 0.000		
Tradeable Spread		0.001 0.030	
N of Tradeable Quotations		0.116 0.000	
Tradeable Volatility		-0.001 0.992	
Spread Ratio			-0.078 0.384
Ratio of Number of Quotations			0.005 0.000
Volatility Ratio			-0.351 0.000
Trade Ratio			0.258 0.099
Asian and London Trading Session	-0.036 0.064	0.042 0.032	-0.033 0.153
London and US Trading Session	-0.098 0.000	0.088 0.000	-0.094 0.000
Adj R-squared	0.202	0.240	0.274

Table A.7.3

Regression Results for the Information Leadership Share of USD/ZAR

This table presents regression results where, for Models 1, 3, 4, and 5, the dependent variable is the information leadership share measure of the indicative price series, and for Model 2, the dependent variable is the information leadership share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.553	0.402	0.370	0.380	0.553	0.402
	0.000	0.000	0.000	0.000	0.000	0.000
Indicative Spread	0.000				0.000	
	0.415				0.415	
N of Indicative Quotations	0.000				0.000	
	0.989				0.989	
Volatility	-0.197				-0.197	
	0.011				0.011	
Tradeable Spread		0.000				0.000
		0.001				0.001
N of Tradeable Quotations		0.041				0.041
		0.000				0.000
Tradeable Volatility		0.048				0.048
		0.512				0.512
Spread Ratio			0.213	0.188		
			0.008	0.019		
Ratio of Number of Quotations			0.000	0.001		
			0.028	0.009		
Volatility Ratio			-0.021	-0.019		
			0.631	0.661		
Trade Ratio			-0.009	-0.072		
			0.959	0.661		
Only Asian Trading Session	0.071	-0.108	0.062		0.071	-0.108
	0.175	0.002	0.097		0.175	0.002
Asian and London Trading Session	0.003	-0.001	-0.010		0.003	-0.001
	0.803	0.906	0.474		0.803	0.906
London and US Trading Session	-0.016	0.013	-0.018		-0.016	0.013
	0.190	0.215	0.134		0.190	0.215
US Trading Session	-0.006	-0.003	0.004		-0.006	-0.003
	0.838	0.874	0.868		0.838	0.874
London Off Hours				0.043		
				0.087		
Active Off Hours						
Local Off Hours						
Adj R-squared	0.138	0.193	0.136	0.130	0.138	0.193

Table A.7.3 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.627	0.409	0.473
	0.000	0.000	0.000
Indicative Spread	0.000		
	0.943		
N of Indicative Quotations	-0.004		
	0.231		
Volatility	-0.177		
	0.000		
Tradeable Spread		0.000	
		0.092	
N of Tradeable Quotations		0.083	
		0.000	
Tradeable Volatility		-0.070	
		0.221	
Spread Ratio			-0.041
			0.429
Ratio of Number of Quotations			0.003
			0.000
Volatility Ratio			-0.091
			0.049
Trade Ratio			0.157
			0.080
Asian and London Trading Session	-0.010	0.002	0.005
	0.430	0.847	0.683
London and US Trading Session	-0.027	0.012	-0.015
	0.026	0.242	0.186
Adj R-squared	0.123	0.222	0.211

Table A.8.1

Regression Results for the Component Share of USD/TRY

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the component share measure of the indicative price series, and for Model 2, the dependent variable is the component share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4
Constant	0.116	0.817	0.394	0.467
	0.378	0.000	0.000	0.000
Indicative Spread	0.000			
	0.817			
N of Indicative Quotations	0.004			
	0.354			
Volatility	0.023			
	0.071			
Tradeable Spread		0.000		
		0.003		
N of Tradeable Quotations		0.012		
		0.823		
Tradeable Volatility		-0.040		
		0.000		
Spread Ratio			-0.161	-0.168
			0.001	0.001
Ratio of Number of Quotations			0.000	0.000
			0.001	0.000
Volatility Ratio			-0.005	-0.006
			0.078	0.089
Trade Ratio			-0.048	-0.105
			0.761	0.493
Only Asian Trading Session	0.134	-0.038	0.122	
	0.005	0.364	0.001	
Asian and London Trading Session	0.031	-0.026	0.027	
	0.229	0.302	0.308	
London and US Trading Session	0.127	-0.101	0.087	
	0.000	0.000	0.001	
US Trading Session	0.218	-0.119	0.174	
	0.000	0.041	0.001	
London Off Hours				0.085
				0.007
Active Off Hours				
Local Off Hours				
Adj R-squared	0.070	0.144	0.169	0.155

Table A.8.1 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	-0.130	0.878	0.448
	0.232	0.000	0.000
Indicative Spread	0.003		
	0.035		
N of Indicative Quotations	0.009		
	0.008		
Volatility	-0.054		
	0.164		
Tradeable Spread		-0.001	
		0.001	
N of Tradeable Quotations		0.049	
		0.430	
Tradeable Volatility		-0.012	
		0.605	
Spread Ratio			-0.261
			0.000
Ratio of Number of Quotations			0.000
			0.760
Volatility Ratio			-0.009
			0.001
Trade Ratio			-0.055
			0.702
Asian and London Trading Session	0.007	-0.020	0.027
	0.811	0.463	0.337
London and US Trading Session	0.104	-0.074	0.064
	0.000	0.002	0.008
Adj R-squared	0.071	0.091	0.201

Table A.8.2

Regression Results for the Information Share of TRY/USD

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information share measure of the indicative price series, and for Model 2, the dependent variable is the information share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4
Constant	0.180	0.742	0.335	0.411
	0.164	0.000	0.000	0.000
Indicative Spread	-0.002			
	0.187			
N of Indicative Quotations	0.006			
	0.184			
Volatility	0.021			
	0.142			
Tradeable Spread		0.000		
		0.463		
N of Tradeable Quotations		0.079		
		0.187		
Tradeable Volatility		-0.040		
		0.000		
Spread Ratio			-0.086	-0.096
			0.093	0.063
Ratio of Number of Quotations			0.000	0.000
			0.216	0.169
Volatility Ratio			-0.004	-0.004
			0.188	0.224
Trade Ratio			-0.013	-0.057
			0.943	0.745
Only Asian Trading Session	0.200	-0.062	0.116	
	0.000	0.214	0.008	
Asian and London Trading Session	0.066	-0.056	0.045	
	0.031	0.063	0.164	
London and US Trading Session	0.135	-0.093	0.087	
	0.000	0.000	0.002	
US Trading Session	0.287	-0.164	0.189	
	0.000	0.023	0.002	
London Off Hours				0.084
				0.027
Active Off Hours				
Local Off Hours				
Adj R-squared	0.060	0.078	0.064	0.054

Table A.8.2 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	-0.022	0.805	0.355
	0.852	0.000	0.000
Indicative Spread	0.001		
	0.526		
N of Indicative Quotations	0.009		
	0.021		
Volatility	-0.062		
	0.124		
Tradeable Spread		-0.001	
		0.191	
N of Tradeable Quotations		0.091	
		0.185	
Tradeable Volatility		-0.011	
		0.667	
Spread Ratio			-0.153
			0.119
Ratio of Number of Quotations			0.000
			0.233
Volatility Ratio			-0.009
			0.001
Trade Ratio			-0.042
			0.816
Asian and London Trading Session	0.040	-0.051	0.044
	0.217	0.113	0.190
London and US Trading Session	0.104	-0.076	0.055
	0.000	0.007	0.051
Adj R-squared	0.043	0.016	0.084

Table A.8.3

Regression Results for the Information Leadership Share of USD/TRY

This table presents regression results where, for Models 1, 3, 4, and, 5, the dependent variable is the information leadership share measure of the indicative price series, and for Model 2, the dependent variable is the information leadership share of the tradeable series. Panel A shows the results for the full sample. Panel B gives the results for only the London market trading hours. Panel C gives the results for only the local market trading hours. P-values are given below the coefficient estimates. Bold figures refer to significance at an alpha level of 10% or better.

Panel A – Full Sample	Model 1	Model 2	Model 3	Model 4
Constant	0.640	0.326	0.348	0.359
	0.000	0.000	0.000	0.000
Indicative Spread	-0.005			
	0.000			
N of Indicative Quotations	0.004			
	0.274			
Volatility	0.012			
	0.397			
Tradeable Spread		0.001		
		0.000		
N of Tradeable Quotations		0.205		
		0.000		
Tradeable Volatility		-0.019		
		0.000		
Spread Ratio			0.154	0.139
			0.011	0.020
Ratio of Number of Quotations			0.000	0.000
			0.009	0.020
Volatility Ratio			0.003	0.004
			0.140	0.064
Trade Ratio			0.149	0.174
			0.286	0.203
Only Asian Trading Session	0.116	0.018	-0.052	
	0.025	0.695	0.182	
Asian and London Trading Session	0.094	-0.084	0.041	
	0.001	0.002	0.158	
London and US Trading Session	0.030	0.016	0.003	
	0.233	0.492	0.905	
US Trading Session	0.156	-0.069	0.035	
	0.006	0.249	0.490	
London Off Hours				-0.030
				0.347
Active Off Hours				
Local Off Hours				
Adj R-squared	0.088	0.146	0.108	0.101

Table A.8.3 (cont'd)

Panel B – London Market Open	Model 1	Model 2	Model 3
Constant	0.789	0.316	0.295
	0.000	0.000	0.000
Indicative Spread	-0.004		
	0.000		
N of Indicative Quotations	-0.001		
	0.685		
Volatility	-0.032		
	0.118		
Tradeable Spread		0.001	
		0.000	
N of Tradeable Quotations		0.139	
		0.014	
Tradeable Volatility		0.006	
		0.798	
Spread Ratio			0.208
			0.007
Ratio of Number of Quotations			0.000
			0.008
Volatility Ratio			0.001
			0.813
Trade Ratio			0.082
			0.619
Asian and London Trading Session	0.089	-0.084	0.047
	0.002	0.003	0.111
London and US Trading Session	0.003	-0.003	-0.017
	0.897	0.910	0.498
Adj R-squared	0.177	0.206	0.135

B. CURRICULUM VITAE

Derya Ezgi KAYALAR

E-mail:

EDUCATION

Ph.D., Middle East Technical University, Business Administration (Finance Track), 2024.

M.Sc., Middle East Technical University, Financial Mathematics, 2014.

B.S., Middle East Technical University, Economics, 2008.

PROFESSIONAL EXPERIENCE

Specialist, Central Bank of the Republic of Turkey, 2013-present.

Specialist, Turkish Derivatives Exchange, 2008-2012.

RESEARCH AND PUBLICATIONS

[1] “The Effects of Non-Deliverable Forward Programs of Emerging Market Central Banks: A Synthetic Control Approach”, Borsa Istanbul Review, Article in Press, March 2024

[2] “Interdependencies across Sovereign Bond Credit Default Swap Markets”, CBRT Working Paper, April 2017

[3] “The impact of crude oil prices on financial market indicators: copula approach”, Energy Economics, 2017, Vol. 61

COMPUTER SKILLS

Stata, EViews, Matlab, Bloomberg, Reuters.

C. TURKISH SUMMARY / TRKE ZET

Bu tez, Reuters Platformu'ndan alınan gsterge niteliindeki kotasyonlar ile Reuters Eşleřtirme Sistemi'nden alınan alınıp satılabilir/kesin kotasyonları karşılařtırarak dviz piyasasındaki fiyat keřif srecinin kapsamlı bir analizini sunmaktadır.

Piyasa mikroyapısı akademik yazını varlık piyasalarındaki davranıřları ve fiyat oluřumunu analiz etmektedir. Bu arařtırmanın temelinde, piyasalarda kullanılan belirli alım satım mekanizmalarının zelliklerinin varlık fiyatlarının davranıřını etkilemede nemli olduđu inancı yatmaktadır (Easley ve O'hara 2003). Piyasa mikroyapısı arařtırmalarının kritik bir alanı, yeni bilgilerin varlık fiyatlarına nasıl dahil edildiđini inceleyen fiyat oluřumu ve keřfi alanıdır.

Dviz piyasası, farklı platform ve ortamlarda gerekleřtirilen iřlemlerle merkezi olmayan bir yapıya sahiptir. İřlemlerin kamuya aıklanan fiyatlarla gerekleřtiđi ve tm yatırımcıların aynı fırsatlarla karşılařtıđı menkul kıymet piyasaları gibi merkezi piyasaların aksine, merkezi olmayan bir sistemde fiyatlar kote edilir ve farklı platformlarda iřlemler gerekleřmektedir. Merkezi olmayan yapının nemli bir sonucu paralanmıř piyasa yapısıdır; bu durumda tm kotasyonlar gzlemlenebilir olmadıđından, iřlemler aynı anda farklı fiyatlardan gerekleřebilmektedir (Sarno ve Taylor, 2001). Sonu olarak, menkul kıymet piyasalarının aksine, dviz piyasasında birden fazla platformda farklı fiyatlar ve alım satım fırsatları sz konusudur.

Piyasa paralanması yođunlařtıķķa, fiyat keřfinin kapsamı ve ynnn incelenmesi nemli hale gelmektedir. Bir varlık hakkındaki yeni bilgiyi ilk olarak hangi piyasanın ierdiđini ve alım satım mekanizmalarının, alım satım faaliyetlerinin ve zel bilginin yaygınlıđının fiyat keřfinin etkinliđini nasıl etkilediđini anlamak, bir piyasadaki genel fiyat keřfi srecini kavramak iin gereklidir.

Bu tezde, dviz piyasasındaki fiyat keřfi, en ok takip edilen kotasyon trleri karşılařtırılarak analiz edilmektedir: Reuters EFX sayfasından alınan gsterge

niteliğindeki kotasyonlar ve Reuters Eşleştirme Sistemi'nden alınan alınıp satılabilir/kesin kotasyonlar. Gösterge niteliğindeki kotasyonlar, küresel olarak tüm piyasa oyuncularının erişebildiği geleneksel bilgi kaynağı iken, kesin kotasyonlar standart bir kapalı emir defterine sahip olan Reuters Eşleştirme Sistemi'nden alınmaktadır. Alım satım konu olan kotasyonların gösterge niteliğindeki kotasyonlarla karşılaştırılması, bu iki kotasyon türünün işlem ortamları nedeniyle önemli yapısal farklılıklara sahip olması sebebiyle, döviz piyasalarındaki fiyat keşfi sürecinin anlaşılmasına farklı alanlarda çeşitli katkılar sağlamaktadır. Söz konusu iki fiyat serisini yapısal farklılıkları arasında ilk olarak, platformların katılımcıları ya da kotasyonların son kullanıcılarının farklı olması yer almaktadır. Reuters Eşleştirme Sistemi'nin kullanıcıları, akademik yazında bilgili yatırımcılar olarak kabul edilen bankalar, finansal kurumlar ve serbest fonlardır. İkinci olarak, Reuters Eşleştirme Sistemi'nin çok seçici yapısına kıyasla EFX gösterge kotasyonlarına çok çeşitli piyasa yapımcıları katkıda bulunmaktadır. Üçüncü olarak, alınıp satılabilir kotasyonlar alım satım yükümlülüklerine tabi iken, gösterge niteliğindeki kotasyonlar çoğunlukla reklam amaçlıdır ancak bu kotasyonları kullanan çalışmalar, bankaların itibar kaygıları nedeniyle ortaya çıktıktan kısa bir süre sonra kullanılmaları halinde kotasyonlarına karşı alım satım yapma olasılığının yüksek olduğunu iddia etmektedir (Martens ve Kofman, 1998). Son olarak, gösterge niteliğindeki kotasyonlar ile işlem yapılabilir kotasyonlar arasında gizlilik açısından asimetri bulunmaktadır, çünkü gösterge niteliğindeki kotasyonlar finansal kuruluşun adını göstererek yayınlanırken, Reuters Eşleştirme Sistemi işlemden önce kotasyon verenin kimliğini göstermemekte, yani bu platformda işlem öncesi taraf gizliliği bulunmaktadır.

Hisse senedi piyasasında fiyat keşfi üzerine çapraz kote hisse senetlerine dayalı çeşitli çalışmalar yapılmış olmasına rağmen, piyasanın oldukça parçalı olması ve çeşitli platformlar için fiyat ve işlem verilerine kolayca erişilememesi nedeniyle bu konu döviz piyasası için yeterince araştırılmamıştır. Konuyla ilgili yapılan az sayıda çalışma bulunmakta ve söz konusu çalışmalar birbiriyle çelişen sonuçlar ortaya koymaktadır. Bu tezde, öncelikle döviz piyasasında 1990'lardan bu yana geçirdiği yapısal değişiklikler ele alınmakta; daha sonra piyasa mikroyapısına ilişkin akademik yazın döviz piyasasında fiyat keşfi özelinde incelenmektedir. Daha sonra, kullanılan veri ve

metodoloji hakkında bilgi verilmektedir; bu kısımda kullanılan farklı piyasa keşfi ölçüm metrikleri incelenmekte ve karşılaştırılmaktadır. Sonuçlar ele alınırken öncelikle fiyat keşfi ölçümlerine ilişkin sonuçlar değerlendirilmekte, daha sonra fiyat keşfi ölçümlerin belirleyicilerine ilişkin analiz sonuçları paylaşılmaktadır.

Geleneksek döviz piyasası yapısı ve bu yapının günümüze kadar geçirdiği değişimleri incelemek döviz piyasasında fiyat keşfi sürecini anlamak için önem arz etmektedir. Başlangıçta döviz piyasasında alım/satım işlemleri mal ve hizmet tüccarları arasında gerçekleşmekteydi. Ancak yüzyıllar içinde bu işlemler spekülasyon, riskten korunma ve arbitraj gibi farklı amaçlara sahip çeşitli piyasa katılımcılarını da içerecek şekilde genişlemiştir. Dolayısıyla, başlıca piyasa katılımcıları şu anda dealerlar, varlık yöneticileri, merkez bankaları, perakende yatırımcılar ve son zamanlarda yüksek frekanslı işlem yapan fonlardır. Uygulamada, işlem yapmak isteyen bir yatırımcı bir dealerlardan belirli bir miktar için kotasyon ister ve dealer hem alış hem de satış bacağı için, müşterinin alım ya da satım yapacağını bilmeden, kotasyon verir. Daha sonra yatırımcı almaya ya da satmaya ya da pas geçmeye karar verir. Geleneksel piyasa yapısı işlemlerin iki ayrı alanda gerçekleştiği bir yapıya sahiptir. İşlemler dealerlar arasında dealerlar arası piyasada, dealerlar ile banka dışı müşterileri arasında perakende piyasada gerçekleşmektedir (Evans, 2010). 1990'ların başlarından önce döviz işlemlerinin en yaygın biçimi dealerlar arası piyasada, genellikle telefon aracılığıyla gerçekleştirilen, doğrudan ticaretti ancak 1990'ların başlarında elektronik işlem platformlarının ortaya çıkmasıyla bu durum değişmiştir. Elektronik işlem platformları 1990'ların sonunda likit paritelerdeki dealerlar arası işlemlere hâkim olmuştur. Bu platformlarda dealerlar işlem yaparken pozisyonlarını gizleyebildikleri ve ayrıca bu platformlar daha hızlı ve operasyonel olarak daha verimli olduğu için dealerlar bu platformları kullanmayı geleneksel yöntemlere göre tercih etmiştir (King ve diğerleri, 2012). Bu dönemde ortaya çıkan, halen de piyasada başlıca elektrik işlem platformu olarak tanımlanan Reuters Eşleştirme Sistemi ile EBS platformu arasında likidite, ağ dışsallıkları nedeniyle her para birimi için bir platformda yoğunlaşmıştır. EUR, JPY ve CHF işlemleri ağırlıklı olarak EBS'de yer alırken, Reuters GBP, AUD, CAD ve diğer para birimlerinin alım satımına hakim olduğu bilinmektedir (King, 2012).

Bu işlem platformları küresel borsaların yanı sıra takas kurumlarının da bazı hizmetlerini sunmaktadır. Söz konusu platformlar standart kapalı emir defterine sahiptir; böylece, işlemler sistem içinde emir eşleştirmesi ile tamamlanır. Bu işlem platformlarında, hiçbir aracı özel olarak likidite sağlamakla görevli olmamakla birlikte her aracı bir limit emri vererek likidite sağlayabilir ya da bir piyasa emri girerek likidite talep edebilir durumdadır (King et al, 2013). Verilen kotasyonlar kesin kotasyonlardır ve işlem yükümlülüklerine tabidir. Doğrudan alım satımdan farklı olarak, dealer ne zaman limit emri göndereceğine ve limit emrinin alınması durumunda işlem görecektir maksimum miktara karar verir. Ayrıca, dealerlar bu sistemlerde sadece alım ya da sadece satım için limit emri gönderebilir. Bu özellik, dealerların çift taraflı kotasyon verdiği doğrudan alım satım işlemlerinden oldukça farklıdır.

1990'lerden günümüze döviz piyasasında yapısal olarak önemli değişikliklerin gerçekleşmesinde temel birkaç etmen rol oynamıştır. Bunlardan ilki yukarıda bahsedildiği gibi elektronik işlem platformlarının ortaya çıkmasıdır. Diğer etmen ise dealer olmayan finansal kurumların işlem yoğunluğunun artmasıdır. Dolayısıyla, 1990'lerden dealerlar arası işlemlerin domine ettiği başlıca elektronik işlem platformları 2000'lerde hem dealer hem de farklı motivasyon ve işlem teknikleri olan dealer olmayan finansal kurumların da işlem yapabildiği platformlara dönüşmüştür. Diğer taraftan, dealer olmayan kurumların piyasadaki varlığının etkisiyle kar marjları düşen dealer kurumlar 2010'lerden sonra geliştirdikleri tek veya çoğul banka platformları üzerinden müşterileri ile işlem gerçekleştirmeye başlamış, genişleyen yatırımcı havuzları ise daha çok işlemin netleştirmesinin kendi havuzlarında yapılmasına yol açmıştır.

Sonuç olarak, günümüzün FX piyasası yapısı, 2000'li yıllardan önce hakim olan, dealerlar arası ve müşteri-dealer segmentlerinin ayrı olduğu geleneksel iki katmanlı piyasa yapısından önemli ölçüde farklıdır. Günümüzde döviz piyasası, birçok işlem platformunun bulunması, katılımcıların çoğunun birden fazla yolla birbirine bağlı olması ve likidite sağlayıcıların sadece dealerlar değil aynı zamanda farklı işlem motivasyonları ve tekniklerine sahip çok çeşitli bir grup olan dealer olmayan kurumlar olması anlamında parçalanmıştır. Piyasada işlem içselleştirme oranı yüksektir ve

dealerlar, algoritmik fonlar tarafından yaygın olarak kullanılan ana işlem platformlarında dominant değildir. Öte yandan, FX piyasası likidite sağlayan başlıca dealerlar ve kurumlar açısından yoğunlaşmıştır. Ayrıca, alım satım işlemleri coğrafi olarak da daha yoğundur. Yüksek içselleştirme oranları ve çeşitli doğrudan/dolaylı işlem platformlarının varlığı, işlem bilgilerinin gizli olduğu bir işlem ortamına yol açmıştır. Geleneksel ortamdaki çok farklı olan, daha az "görünür" ticaret ve daha fazla piyasa parçalanması içeren günümüzün döviz piyasası ortamının fiyat keşif süreci ve piyasa işleyişi kapsamında önemli sonuçları olduğu değerlendirilmektedir.

Piyasa mikroyapısı alandaki akademik yazın incelendiğinde piyasa mikroyapısı yaklaşımının ortaya çıkışı ve daha sonra geliştirilen modellerin ilk başta hisse senedi piyasasını temel aldığı ve döviz piyasasını dikkate alan piyasa mikroyapısı yaklaşımının ise yaklaşık on yıl sonra başladığı görülmektedir. Sabit döviz kuru rejimleri 1970'lerde terk edildikten sonra, ekonomistler veri eksikliği nedeniyle tümevarımsal olarak kısıtlanmış modeller geliştirmişlerdir. Geliştirilen modellerin kısa dönem döviz kuru hareketlerini tahmin etmedeki başarısızlığı araştırmacıları dealerların piyasa anlayışını öğrenmeye ve dealerların piyasa işleyişine ilişkin görüşlerini test etmeye yöneltmiştir (King et al, 2013). Döviz piyasası mikroyapısı çalışmaları bu alanda şekillenerek, emir akışının getiriler üzerinde kalıcı etkisi olduğunu göstermiştir. Daha sonra akademisyenler döviz piyasasındaki fiyat oluşum sürecini açıklamak için farklı varsayımlara dayanan teorik modeller geliştirmiştir. Evans and Lyons tarafından geliştirilen (2002) ve döviz piyasası yapısının birçok önemli özelliğini barındıran model bu alandaki en önemli modellerdendir. Söz konusu modelde üç tür işlem yapılmakta ve işlem yapma amacı farklı olan iki grup müşteri bulunmaktadır. Modeldeki dealerlar her işlem günü sonunda pozisyonlarını sıfırlamayı amaçlamaktadır. Modelde, dealerlar birinci turda karşılaştıkları müşterilerin döviz talebini fiyatları yeterince değiştirerek ikinci turda işlem yaptıkları müşteri grubuyla dengelemektedir. Dolayısıyla, söz konusu model döviz talebine ilişkin değişen talebin dealerların emir akışını gözlemleyerek ulaştığını varsayarak emir akışının getirileri etkilemesine ilişkin teorik bir alt yapı sunmaktadır. Ayrıca model, farklı müşteri segmentlerinden gelen emir akışlarının fiyat etkisinin farklı olduğunu göstermektedir.

Bu alandaki diğer önemli teorik çalışma Osler ve diğerleri (2011) tarafından gerçekleştirilmiştir. Çalışmada araştırmacılar müşteri piyasası ve dealerlar arası piyasa ayırımına dayanarak döviz piyasalarındaki fiyat keşfi sürecinin ayrıntılı bir resmini sunmayı amaçlamakta, döviz piyasalarında fiyat keşfinin, döviz piyasasının iki katmanlı yapısına paralel olarak üç aşamadan oluştuğunu varsaymaktadırlar. İlk aşamada dealerlar müşterileriyle işlem yaparak, özel bilgiye ilişkin bir işaret elde eder; ancak, bu aşamada dealerlar alım-satım farkını genişletmezler çünkü bilgili müşteriden özel bilgisine ilişkin yön tayin etmeyi amaçlarlar. Dolayısıyla, özel bilgi bu aşamada işlem fiyatını etkilemez. İkinci aşamada, dealerlar bu özel bilgiden kar elde etmek için dealerlar arası piyasada agresif bir işlem yaparak alış-satış farkını etkiler. Böylece, dealerlar arası piyasada fiyat keşfinin standart paradigmayı takip etmesi beklenir. Üçüncü aşamada ise fiyatlar yeni bilgiyi yansıtacak şekilde dealerlar arası kotasyonlara dayanır. Böylece fiyat keşfi süreci tamamlanır. Ampirik kanıtlar bu üç aşamalı fiyat keşif sürecini desteklemektedir. Osler ve diğerleri (2011), dealerların genellikle bilgilendirilmiş müşteri işlemlerinden sonra agresif bir şekilde işlem yaptığını bulmuştur.

Döviz piyasası yapısını ele alan çeşitli teorik mikro yapı modelleri emir akışının, özel bilginin ve piyasa katılımcılarının heterojenliğinin döviz kurlarının belirlenmesindeki önemini vurgularken fiyat keşif sürecinin altında yatan mikro yapı mekanizmalarının kapsamlı bir şekilde anlaşılmasını sağlamaktadır. Bu alandaki teorik modellerin genel olarak bu çalışmayı ilgilendiren üç önemli çıkarımı bulunmaktadır. Bunlardan ilki, müşteriler arasındaki heterojenliğin fiyat oluşum sürecinde önemli bir role sahip olduğudur. İkincisi, bir platformdaki fiyatın, farklı müşteri ve işlemciler sebebiyle başka bir platformdaki fiyatın önüne geçebileceği veya gerisinde kalabileceğidir. Üçüncüsü ise fiyat keşfi için ana platformun, dealerlar arası işlem platformu olduğudur.

Bu alandaki ampirik çalışmalar ise fiyat keşfinin gerçekleştiği birkaç temel mekanizma tanımlamış ve bu sürecin karmaşıklığının altını çizmiştir. Akademik yazında emir akışı, özel bilgi, likidite, piyasa oyuncularının türleri ve döviz piyasalarındaki piyasa

mikro yapısıyla ilgili konular bu karmaşık sürecin anlaşılması için önemli olarak tanımlanmakta, çalışmalar bu alanlarda yoğunlaşmaktadır.

Özel bilgi ve piyasa katılımcılarının heterojenliğinin fiyat keşfine etkisi alanındaki ampirik çalışmalar piyasa katılımcılarının kimliğinin döviz kurlarının bilgi içeriğini etkilediğini göstermektedir. Bulgular, merkez bankalarının en büyük fiyat etkisine sahipken, bunu banka dışı finansal kuruluşların takip ettiğini, finansal olmayan şirketlerin işlemlerinin ise en az etkiye sahip olduğunu göstermiştir. Çalışmalar ayrıca, daha fazla özel bilgiye sahip olan dealerların, daha düşük işlem hacmine sahip olan doğrudan ticareti tercih ettiğini göstermektedir (Carpenter ve Wang, 2007). Piyasanın mikro yapısının fiyat keşfi sürecine etkisi üzerine de akademik yazında önemli bulgular yer almaktadır. Bulgular, elektronik sistemlerin döviz piyasası likiditesini artırdığını ve alım-satım farkları ile piyasa likiditesindeki coğrafi farklılıkları azalttığını göstermektedir (Ding ve Hiltro, 2010). Chaboud ve diğerleri (2021) temel işlem platformlarında fiyat keşfinin daha hızlı hale geldiği ve bunun da piyasa verimliliğinde iyileşmelere yol açtığını göstermektedir. Ayrıca, bulgular bilgili müşterilerin büyük finans merkezleri üzerinden işlem yaptığını ve işlemlerin Londra ve New York gibi büyük bir döviz merkezinde başlatıldığında daha bilgilendirici olduğuna işaret etmektedir (D'Souza, 2007; Moore ve Payne, 2010).

Hisse senedi piyasasında fiyat keşfi üzerine çapraz kote hisse senetlerine dayalı çeşitli çalışmalar yapılmış olmasına rağmen, piyasanın oldukça parçalı olması ve çeşitli platformlar için fiyat ve işlem verilerine kolayca erişilememesi nedeniyle bu konu döviz piyasası için yeterince araştırılmamıştır. Goodhart ve diğerleri (1995) gösterge niteliğindeki ve alım satım konu olan kotasyonları karşılaştırarak serilerin zaman serisi özelliklerinin benzer olduğunu ancak alış-satış farklarının dağılımının önemli ölçüde farklı olduğunu göstermektedir. Danielsson ve Payne (2002) fiyat keşfinin ağırlıklı olarak alınıp satılabilir kotasyonlarda gerçekleştiğini, ilgili bilginin %90'ından fazlasının önce alınıp satılabilir kotasyonlara ve daha sonra gösterge kotasyonlara dahil olduğunu ortaya koymaktadır. Buna karşılık, Phylaktis ve Chen (2009) gösterge niteliğindeki kotasyonların bilgi payının yaklaşık %80 olduğunu ve Matching sistemindeki işlemlerde işlem sıklığında önemli bir artış olduğunda gösterge niteliğindeki verilerin daha yüksek bilgiye sahip olduğunu göstermektedir.

Dolayısıyla, konuyla ilgili yapılan az sayıdaki çalışmalar birbiriyle çelişen sonuçlar ortaya koymaktadır.

Bu çalışmada kullanılan veri seti çeşitli döviz kurlarının, 10 Ağustos 2020 ile 30 Kasım 2020 arasındaki gün içi tik verilerini içermektedir. Çalışmada kullanılan döviz kurları ve veriler çeşitli filtrelerden geçirilmiş ve nihai çalışma sekiz döviz kuru üzerine yapılmıştır. Kullanılan gösterge kotasyonlar Reuters EFX sayfası verileridir ve kotasyon zamanı, en iyi alım/satım verileri, kotasyon giren kuruluş ve şehir bilgilerini içermektedir. Kesin kotasyonlar ise Reuters Eşleştirme Sistemi verileridir ve kotasyon zamanı en iyi alım/satım kotasyonları, işlem fiyatı ve işlemi tetikleyen taraf göstergesi içermektedir. Veriler, tatil günleri, eksik kotasyonlar, negatif alım-satım farkları ile birebir aynı zamanda girilen kotasyonlar dikkate alınarak filtelenmiştir. Söz konusu döviz kurlarının alım-satım farkları ve kotasyonlar sayıları incelendiğinde gün içi mevsimselliğin önemli olduğu gözlemlenmiş, bu kapsamda çalışma bir işlem günü 8 eşit parçaya bölünmüş ve bu parçalar dikkate alınarak analizler yapılmıştır.

Çalışmada iki aşamalı analizler yapılmış, ilk aşamada gösterge ve kesin kotasyonların fiyat keşfi oranları tahmin edilmiştir. Bu kapsamda literatürde yaygın olarak kullanılan iki ölçütten yararlanılmıştır. Kullanılan üçüncü ölçüt ise daha sonradan geliştirilen bir ölçüttür. Kullanılan fiyat keşfi ölçütlerinden ilki Hasbrouck (1995) tarafından geliştirilen bilgi payı ölçütüdür. Hasbrouck (1995), örtük etkin fiyatın tüm piyasalar için ortak olduğunu ve bu etkin fiyattaki varyasyon kaynaklarının farklı piyasalara atfedildiğini savunmaktadır. Dolayısıyla, bu çerçevede fiyat keşfinin etkin fiyattaki inovasyona atıfta bulunduğunu iddia etmekte ve bilgi payını bir piyasanın fiyat keşfine katkısı olarak tanımlamaktadır. Bu kapsamda, bilgi payı ölçütünü etkin fiyattaki inovasyon varyansının söz konusu piyasaya atfedilebilecek oranı olarak hesaplamaktadır. Buna karşın, Booth ve diğerleri (1999), Chu ve diğerleri (1999) ve Harris ve diğerleri (2002), Gonzalo ve Granger'ın (1995) kalıcı-geçici ayrıştırma tekniğini benimseyerek etkin fiyat inovasyonunun bileşimine odaklanmış ve bir piyasanın fiyat keşfine katkısını, o piyasanın etkin fiyat inovasyonunu oluşturmadaki bileşen payı ile ölçmüştür. Bu ölçütlere ek olarak Putnins (2013), Yan ve Zivot'un (2010) çalışmasına dayanan bilgi liderliği ölçütünü önermektedir. Bu ölçü, bilgi payı

ve bileşen payı ölçülerini birlikte kullanarak, yeni bilgiyi ilk kapsayan fiyat serisini belirlemektedir.

Fiyat keşfinin, temel değere ilişkin bilginin etkin ve zamanında fiyata dahil edilmesi olarak tanımlanmasının iki boyutu yer almaktadır. İlk boyut, bilginin fiyatlara zamanında dahil edilmesidir; bu boyut tamamen hız ile ilgilidir. İkinci boyut ise bilginin fiyatlara etkin bir şekilde dahil edilmesidir; bu boyut ise gürültü ile ilgilidir. Putnins (2013) fiyat keşfi metriklerinin gerçekte neyi ölçtüğünü, fiyat serilerinin gürültü ve yeni bilgiye uyum hızı açısından farklılık göstermesine izin veren basit bir yapısal modele dayanan simüle edilmiş veriler üzerinde her bir fiyat keşfi metriğini tahmin ederek incelemiştir. Çalışma, bilgi ve bileşen payı metriklerinin, karşılaştırılan fiyat serileri benzer gürültü seviyelerine sahip olduğunda, yeni bilginin temel fiyata yansıma hızını ölçtüğünü ortaya koymaktadır. Çalışma aynı zamanda, fiyat serileri farklı gürültü seviyelerine sahip olduğunda, bileşen payı ve bilgi payı ölçütlerinin fiyatların yeni bilgileri içirme hızının yanı sıra değişen derecelerde gürültüden kaçınmayı da ölçtüğünü göstermektedir. Çalışmadaki simülasyonlar, bilgi payı metriğinin bileşen payı metriğine kıyasla hızla daha fazla ağırlık verdiğini gösterirken; simülasyon sonuçları ayrıca, bilgi liderliği metriğinin farklı gürültü seviyelerinin varlığında bile sadece yeni bilgi edinme hızını ölçtüğünü göstermektedir. Genel olarak simülasyonlar, bileşen payı metriğinin yüksek hızla kıyasla düşük gürültüye, bilgi payı metriğinin düşük gürültüye kıyasla yüksek hızla ve bilgi liderliği metriğinin sadece yüksek hızla daha fazla önem atfettiğini göstermektedir. Putnins'in (2013) söz konusu çalışması farklı varlık sınıflarının rolü ve fiyat türleri de dahil olmak üzere daha önce incelenen konulara ilişkin sonuçların, fiyat keşif metriğinin seçimine bağlı olarak önemli ölçüde değişebileceğini ima etmektedir. Bu kapsamda, gösterge niteliğindeki ve alım satıma konu olan kotasyonların fiyat keşif payları incelenirken, gösterge niteliğindeki ve alım satıma konu olan fiyat serilerinin farklı gürültü seviyelerine sahip olması beklendiğinden, fiyat keşif ölçütlerinin serilerin hızına ve gürültüsüne göreceli olarak odaklanmasına ilişkin tartışmaların dikkate alınması kritik önem taşımaktadır.

Elder ve diğerleri (2014) yüksek frekanslı verilerin bilgi payının daha hassas bir şekilde tahmin edilmesini sağladığını savunmaktadır. Bu durum, yüksek frekanslı fiyat

verilerinin düşük korelasyonunun, fiyat keşfini tek bir seriye atfederken modelin daha iyi performans göstermesini sağladığını savunan Baillie ve diğerleri (2002) ile uyumludur. Bu nedenle, fiyat serileri oluşturulurken 1 saniyelik örneklem sıklığı kullanılmıştır. 1 saniyeden daha düşük bir örneklem sıklığının (örneğin 5 veya 10 saniye) vektör hata düzeltme modellerindeki artık korelasyon seviyelerini artırarak fiyat keşfi ölçümlerinin tahminini sorunlu hale getirdiği gözlemlenmiştir.

Çalışmada her bir kur ve her günün bölümleri için fiyat keşfi metrikleri tahmin edildiğinden, bunun için sırasıyla açıklanan adımlar izlenmiştir: İlk olarak, log orta fiyatlar ve log orta fiyatlardaki değişim için Augmented Dickey Fuller testi uygulanarak serilere durağanlık testi yapılmıştır. İkinci olarak, iki serinin log orta fiyatları arasındaki Johansen eşbütünleşme testine dayalı olarak test edilmiştir. Üçüncü olarak, sonuçların bir adet eşbütünleşik denkleme işaret ettiği seriler analiz için seçilmiştir. Dördüncü olarak, vektör otoregresyon modelinde 60'a kadar en uygun gecikme yapısı Bayes Bilgi Kriterine göre seçilmiştir. Ardından, vektör hata düzeltme modeli bir önceki aşamada seçilen gecikme yapısı ile tahmin edilmiştir. Tahmin edilen vektör hata düzeltme modeline dayanarak bileşen payı ve bilgi payı ölçütleri hesaplanmıştır. Fiyat serilerinin sıralaması değiştiğinde bilgi payı tahminleri değişebildiğinden sıralama değiştirilerek minimum ve maksimum bilgi payı ölçütleri hesaplanmıştır. Nihai bilgi payı ölçütü ise akademik yazında önerildiği gibi, iki olası sıralamanın her biri altındaki bilgi paylarının basit ortalaması alınarak hesaplanmıştır. Daha sonra, önceki adımlarda elde edilen bileşen ve bilgi payı ölçütlerine dayalı olarak bilgi liderliği ölçütleri hesaplanmıştır. Son adımda, vektör hata düzeltme modeli artık korelasyonunun 0,35'in üzerinde olduğu tahminler, bu seviyenin üzerindeki artık korelasyonlar geniş bir değişkenlik aralığına sahip bilgi payı değerleri ürettiğinden, elenmiştir.

Analiz sonuçlarının ilk kısmında veri analizi ön sonuçları paylaşılmıştır. Öncelikle, döviz piyasasında alım satım farkları ve kotasyonların gün içi mevsimselliği incelenmiştir. İşlem ve kotasyon girme aktivitesinin Londra ve ABD'nin işlem saatlerine büyük ölçüde karşılık gelen bir zaman aralığı olan 6 ila 18 GMT arasında yüksek olduğu, işlem yapılabilir kotasyon sayısının işlem sayısı ile yakından ilişkili

olduğu, gösterge niteliğindeki kotasyon sayısının da işlem sayısı ve işlem yapılabilir kotasyon sayısına benzer şekilde gün içi mevsimsel eğilimler gösterdiği görülmüştür. Gösterge niteliğindeki kotasyon sayısı ile işlem yapılabilir kotasyon sayısı arasındaki ilişkinin bazı para birimleri için daha güçlü (AUD/USD, USD/CAD, USD/SGD ve NZD/USD) olduğu izlenirken, bazı para birimleri için daha zayıf (USD/ZAR, USD/MXN ve USD/TRY) olduğu görülmüştür. Gösterge ve işlem yapılabilir alı-satım farkları arasındaki ilişkinin de zayıf olduğu görülmüştür. AUD/USD, USD/CAD, GBP/USD, NZD/USD hariç para birimlerinin çoğunda U şeklinde bir spread modeli gözlenmiştir. Sonraki aşamada orta kotasyonlar üzerinden hesaplanan getiriler baz alınarak iki seri arasındaki çapraz korelasyonlar incelenmiştir. Döviz kurlarının çoğu için, bir gecikmedeki çapraz korelasyonlar 5 saniyelik ve 10 saniyelik frekanslarla oluşturulan serilerde anlamlı bulunmuş, düşük frekanslar için anlamlı olmadığı görülmüştür. Bu durum 1 saniye olarak seçilen örneklem frekansının isabetli olduğuna işaret etmiştir. Ayrıca, daha önce bahsedildiği üzere, fiyat keşfi metriğinin seçimi özellikle analiz edilen iki serinin farklı gürültü seviyelerine sahip olduğu durumlarda önem arz etmektedir. Bu bağlamda, gösterge kotasyonlar ile kesin kotasyonlara ilişkin serilerin, 1 saniyelik orta kotasyon getirileri üzerinden, varyans seviyeleri analiz edilmiştir. Sonuçlar, gösterge seri varyansının kesin kotasyonlara ilişkin seriden istatistiki olarak anlamlı seviyede yüksek olduğunu (USD/SGD hariç) göstermiştir.

Daha sonra fiyat keşfi metriklerine ilişkin sonuçlara yer verilmiştir. Fiyat keşfi metriği, yeni bilgilerin ne kadarının ilgili serilere ilk olarak yansıtıldığını ölçtüğünden, sonuçlar, fiyat keşfi için baskın platformun, döviz çiftlerinde önemli farklılıklar göstermekle birlikte, genel olarak Reuters Eşleştirme Sistemi (kesin alım/satım kotasyonlarının bulunduğu platform) olduğunu göstermektedir. Ortalama olarak, gösterge niteliğindeki fiyat kotasyonlarının maksimum bileşen payları USD/ZAR için %33'e ulaşırken, bunu USD/TRY için %27 takip etmektedir; en düşük değerler ise sırasıyla %2 ve %5 ile USD/CAD ve AUD/USD'ye aittir. Bilgi payı ölçümleri, bileşen payı ölçümleriyle benzer sonuçlar göstermektedir. Bilgi liderliği ölçütüne ilişkin olarak, gösterge niteliğindeki kotasyonların fiyat keşif paylarının bazı döviz kurları için (USD/ZAR) neredeyse %50'ye ulaştığı, en düşük bileşen ve bilgi payı ölçütlerine sahip döviz kurları için ise bilgi liderliği ölçütünün %40'ın üzerinde olduğu

görülmektedir. Bu bulgular, fiyat keşfi ölçütünün seçiminin önemini vurgulamaktadır. Konuyla ilgili daha önceki çalışmalar bilgi payı ölçütlerine dayalı çelişkili sonuçlar sunmaktadır. Danielsson ve Payne (2002) fiyat keşfinin ağırlıklı olarak kesin kotasyonlarında gerçekleştiğini göstermekte, çalışmaya göre ilgili bilginin %90'ndan fazlası önce kesin kotasyonlarına girmekte ve daha sonra gösterge kotasyonlara yansımaktadır. Ancak, Phylaktis ve Chen (2009) gösterge niteliğindeki kotasyonların bilgi payının yaklaşık %80 olduğunu bulmuştur. Bu tez kapsamında yapılan çalışmanın sonuçları Danielsson ve Payne'nin (2002) bulgularını desteklemektedir. Ancak, bilgi liderliği ölçütü dikkate alındığında, gösterge niteliğindeki kotasyonların fiyat keşif payı neredeyse %50'ye ulaşmaktadır, bu da gösterge niteliğindeki kotasyonların kesin kotasyonlardan daha fazla gürültüye sahip olmakla birlikte, yeni bilgilerin neredeyse %50'sinin gösterge niteliğindeki kotasyonlarda toplandığını göstermektedir. Sonuçlar ayrıca gösterge niteliğindeki kotasyonların fiyat keşif payında zaman dilimleri açısından farklılıklar olduğunu göstermektedir. Bu farklılıklar özellikle bileşen ve bilgi payı ölçütleri dikkate alındığında daha belirgin hale gelmektedir. Para birimlerinin çoğu için, gösterge niteliğindeki kotasyonların fiyat keşif payının, çoğu para birimi için inaktif saatlere karşılık gelen 1, 2 ve 7 numaralı zaman dilimlerinde en yüksek olduğu ve aktif saatlere karşılık gelen 3, 4, 5 ve 6 numaralı zaman dilimlerinde en düşük olduğu U şeklinde bir model gözlemlenmektedir.

Fiyat keşfi metrikleri tahmin edildikten sonra bu metriklerin bağımlı değişken, çeşitli piyasa değişkenleri ve işlem oturumu değişkenlerinin ise bağımsız değişken olarak kullanıldığı çeşitli modeller en küçük kareler yöntemiyle tahmin edilmiştir. Modellerde kullanılan piyasa değişkenleri, akademik yazında fiyat keşfi ile ilişkilendirilen değişkenler dikkate alınarak seçilmiştir. Hisse senedi piyasalarında çapraz kote hisse senetlerine ilişkin literatür, bir piyasanın fiyat keşif payının o piyasadaki işlemlerin payı ile pozitif ilişkili olduğunu ve alış-satış farklarının oranı ile ters ilişkili olduğunu göstermektedir (Eun ve Sabherwal, 2003; Frijns vd., 2010; Frijns vd., 2015). Alış-satış farkları ile temsil edilen likiditenin, satıcılar ve müşteriler için bir işlem maliyetini temsil ettiğinden, döviz piyasalarında fiyat keşfi üzerinde de bir etkisi olması beklenmektedir. Benzer şekilde, işlem aktivitesinin de gösterge ve alınıp

satılabilir/kesin kotasyonlar arasındaki görelî fiyat keşfinin belirleyicilerinden biri olması beklenmektedir. Ne yazık ki, EFX sayfası verileri kapsamında işlem veya hacim verileri mevcut değildir. Öte yandan, Reuters Eşleştirme Sistemi'nden alınan veriler ile işlem sayısını hesaplamak mümkündür. İncelenen mevsimsellik örüntüleri, alım satım konu olan kotasyon sayısının işlem sayısı ile yakından ilişkili olduğunu, gösterge niteliğindeki kotasyonların sayısının da işlem sayısı ve alınıp satılabilir kotasyon sayısına benzer şekilde gün içi mevsimsel kalıplar gösterdiğini ortaya çıkardığından bu kalıpları takiben, işlem sayısı, işlem yapılabilir kotasyon sayısı ve gösterge niteliğindeki kotasyon sayısı piyasa aktivitesinin göstergeleri olarak kullanılmıştır. Diğer taraftan, BIS Piyasa Komitesi Raporu (2018), piyasada stres dönemlerinde döviz piyasası işlemlerinin birincil işlem platformlarında kümelendiğini, çünkü bu platformların yüksek likidite ve işlem öncesi taraf gizliliği sağladığını savunmaktadır. Dolayısıyla, BIS Piyasa Komitesi Raporu (2018)'na göre birincil işlem platformları, FX piyasası oynaklığının arttığı dönemlerde fiyat keşfinde önemli bir role sahiptir. Bu argümanı takiben, fiyat oynaklığı da analize dahil edilmiştir.

Bilindiği üzere döviz piyasaları günde 24 saat açıktır ve dünya çapında çeşitli zaman dilimlerinde ve konumlarda faaliyet göstermektedir. Bu kapsamda, farklı faaliyet seviyeleri ve farklı piyasa oyuncuları nedeniyle, döviz piyasasında işlem hacmi, likidite ve piyasa davranışının farklı zaman dilimlerinde ve lokasyonlarda değişiklik göstermesi beklenmektedir. Akademik yazın da, benzer şekilde, farklı zaman dilimleri ve lokasyonlarının fiyat keşif süreci üzerinde etkisi olduğunu göstermektedir. D'Souza (2007) Londra ve New York gibi büyük bir döviz merkezinde başlatılan işlemlerin daha bilgilendirici olduğunu göstermiştir. Wang ve Yang (2011), döviz piyasalarında fiyat keşfinin Avrupa ve ABD işlem saatleri tarafından domine edildiğini bulmuştur. Gençay ve Gradojevic (2013) sabah ve öğleden sonra yapılan işlemlerin özel bilgi içeriğinin yüksek olduğunu göstermiştir. Bu bulgular ışığında, zaman dilimleri ve zaman dilimleri de analize dahil edilmiştir.

Analiz sonuçları seçilen açıklayıcı değişkenlerin fiyat keşfi ölçütlerindeki değişimi açıklamada başarılı olduğunu göstermiştir. Düzeltilmiş R-kare değerlerinin birçok

döviz kuru için yüksek olduğu görülmüştür. Bulgular, alış-satış farkı oranı, kotasyon sayısı oranı ve oynaklık oranının fiyat keşfi ölçütlerindeki değişimi açıklamada önemli piyasa değişkenleri olduğunu göstermektedir.

Oynaklık oranının, bileşen ve bilgi payı ölçütleri ile ilişkisi birçok döviz kuru için çoğunlukla anlamlı bulunmuş ve gösterge kotasyonların fiyat keşif payı ile negatif ilişkili olduğu gösterilmiştir. Bu durumun söz konusu ölçütlerin, serilerin gürültü seviyesine de odaklanmasıyla ilişkili olduğu değerlendirilmiştir. Putnins'in (2013) simülasyonlarına göre bilgi ve bileşen payı ölçütlerinin, yeni bilgilerin elde edilmesindeki liderlik (görelî hız) ile gürültüden görelî kaçınmanın bir kombinasyonunu farklı derecelerde ölçtüğünü ancak bilgi liderliği ölçütünün sadece hızı ölçtüğünü göstermekte olduğu; bu kapsamda, gürültü ile pozitif ilişkili olması beklenen volatilitenin bileşen ve bilgi payı metrikleri için anlamlı olması, ancak bilgi liderliği metriği için anlamlı olmamasının şaşırtıcı olmadığı düşünülmektedir.

Kotasyon sayısı oranı ise genel olarak bilgi liderliği payı ile pozitif ve anlamlı ilişkili bulunurken, diğer ölçütlerle ilişkisi genel olarak istatistiki olarak anlamlı bulunmamıştır. Kotasyon sayısı oranının bilgi liderliği payı ile pozitif ilişkili olması döviz kuru seviyesi hakkında yeni bilgiler içeren alım satım faaliyetini temsil etmesi kaynaklı olduğu düşünülmüştür. Daha önce açıklandığı üzere, bileşen ve bilgi payı ölçütleri fiyat keşfi açısından gürültü ve hıza birlikte odaklanmaktadır. Dolayısıyla, bu ölçütlerin hesaplanması sırasında gürültü için yapılan düzeltme nedeniyle, gösterge serisindeki kotasyon sayısı arttıkça bu ölçütlerin büyüklüğünün azaldığı düşünülmektedir. Öte yandan, bilgi liderliği ölçütü sadece fiyat keşif hızına odaklandığından, gösterge serilerdeki kotasyon sayısının alım satılabilir/kesin serilerdeki kotasyon sayısına kıyasla artmasının, kotasyonların döviz kurunun seviyesi hakkında yeni bilgiler aktarması nedeniyle bilgi liderliği ölçütünde artışa yol açtığı değerlendirilmektedir. Modellere dahil edilen bir diğer piyasa faaliyeti değişkeni de işlem oranıdır; ancak bu değişkenin fiyat keşfi ölçütleri üzerinde anlamlı bir etkisi bulunamamıştır. Sonuçlar ayrıca alış-satış farkı oranının gösterge kotasyonların bileşen ve bilgi payı ölçütleriyle ters, bilgi liderliği ölçütüyle ise pozitif ilişkili olduğunu göstermektedir. Gözlenen bu farklılığın fiyat keşfi ölçümlerinin odak

noktasındaki farklılaşmanın bir sonucu olduğu düşünülmektedir. Bilgi liderliği ölçütünün, yalnızca bilginin hızına odaklanarak, kesin alım-satım farkının gösterge niteliğindeki kotasyonların fiyat keşfi üzerindeki etkisini ayrıştırabildiği düşünülmektedir. Ayrıca, bilgi liderliği ölçütünün sonuçları, Reuters Eşleştirme Sistemi'nin dealerlar arası bir platform olarak hareket ettiğini ve alım-satım farkının Osler'in (2011) dealerların bilgili müşterileri belirleyebildiklerinde alış-satış farklarını genişlettiklerini öngören modeli ile uyumlu olduğunu göstermektedir.

Ayrıca, işlem seansı değişkenlerinin bileşen ve bilgi payı ölçümleri üzerinde anlamlı bir etkisi olduğu bulunmuştur. Literatürde belirtildiği üzere, fiyat keşif süreci işlem seanslarından ve farklı lokasyonlardaki yatırımcıların heterojenliğinden etkilenmektedir. Örneğin, para birimlerinin çoğu için, Londra ve ABD işlem saatlerinde uluslararası finans kuruluşları ve büyük dealerların uluslararası işlemleri piyasada önemli yer tutmaktayken, yerel piyasa saatlerinde yurtiçi bankalar işlem aktivitesine hakimdir. Piyasa oyuncularının işlem tarzları, amaçları ve bilgi setleri farklı olduğundan ve karşılaştırılan iki kotasyon tipi genel olarak farklı piyasa oyuncularını temsil ettiğinden, işlem seanslarının gösterge/alım satım kotasyonlarının fiyat keşif paylarını etkilemesi beklenmektedir. Reuters Eşleştirme Sistemi genellikle finansal kurumlar ve dealerlar tarafından kullanılırken, gösterge kotasyonlar dealerlar veya yerel bankalar tarafından kote edilmektedir. Dolayısıyla, bu argümanlar doğrultusunda, Londra işlem saatlerinde kesin kotasyonların fiyat keşif payının yüksek olması beklenmektedir. Buna paralel olarak, gösterge niteliğindeki kotasyonların fiyat keşif payının özellikle Asya yerel piyasasının açık olduğu para birimleri için Asya işlem saatlerinde daha yüksek olduğu görülmektedir. ABD işlem saatlerine ilişkin bulgular ise gösterge niteliğindeki kotasyonların fiyat keşif payının yerel piyasaları açık para birimler için düşükken, yerel piyasaları kapalı para birimleri için yüksek olduğunu göstermiştir. Özetle, bulgular, gün içi seansları tanımlayan değişkenlerin de kotasyonların fiyat keşif payları üzerinde önemli etkiye sahip olduğunu ve fiyat keşif sürecini değerlendirirken farklı piyasaların (Londra, ABD veya yerel piyasalar gibi) açık olup olmadığını dikkate almanın önemini vurgulamaktadır.

Bu tezin akademik yazına çeşitli katkıları bulunmaktadır: İlk olarak, güncellenmiş veriler kullanılarak, fiyat keşfinde hangi kotasyon tipinin lider olduğuna ilişkin akademik yazındaki mevcut belirsizlik açıklığa kavuşturulmuştur. İkinci olarak, bu çalışma döviz piyasasında 1990'lardaki geleneksel ortamdan bu yana yaşanan önemli yapısal değişiklikleri ve döviz piyasasının güncel parçalı yapısını dikkate alarak fiyat keşfi sürecine ilişkin anlayışımızı geliştirmek için bu konuyu yeniden ele almaktadır. Günümüz FX piyasası çok sayıda işlem platformunun bulunması, katılımcıların çoğunun birden fazla yolla birbirine bağlı olması ve likidite sağlayıcıların sadece dealerlar değil aynı zamanda dealer olmayan kurumlar da olması kapsamında oldukça parçalı bir yapıya sahiptir. Öte yandan, FX piyasası likidite sağlayan başlıca dealer ve kurumlar ile işlemlerin coğrafyası açısından ise yoğunlaşmıştır. Geleneksel döviz piyasası ortamından günümüz döviz piyasasına yaşanan söz konusu yapısal değişikliklerin fiyat keşfi süreci üzerinde önemli etkileri olduğu düşünüldüğünden, bu konunun yeniden ele alınmasının önemli olduğu değerlendirilmektedir. Üçüncü olarak, mevcut akademik yazın, farklı piyasa platformlarının fiyat keşif paylarını incelerken, özellikle piyasa sürtünmelerindeki farklılıklar nedeniyle fiyat serilerinin gürültü seviyeleri farklı olduğunda, farklı fiyat keşif ölçütlerinin serilerin hızına ve gürültüsüne farklı seviyelerde odaklandığını göstermektedir (Putnins, 2013). Bu kapsamda, bu çalışmada, serilerin hızı ve gürültüsüne farklı seviyelerde odaklanan üç fiyat keşif ölçütü, yani bileşen payı, bilgi payı ve bilgi liderliği payını kullanılarak gösterge ve kesin kotasyonlar arasındaki fiyat keşif süreci araştırılmaktadır. Son olarak, akademik yazın ve anekdot niteliğindeki kanıtlar, fiyat keşif sürecinin genel piyasa likiditesi ve derinliğinin yanı sıra bilgi ortamını etkileyebilecek kurumsal faktörlere bağlı olarak döviz kurları arasında farklılık gösterebileceğini göstermektedir. Bu nedenle, fiyat keşif sürecinde farklılıkları gözlemleme fırsatı vermesi amacıyla incelenen döviz kurları kapsamlı tutularak farklı piyasa likiditesi seviyelerine sahip döviz kurları örnekleme dahil edilmiştir.

Bu çalışmanın sonuçları, özetle, özellikle bilgi ve bileşen payı ölçümleri dikkate alındığında, döviz kurlarında önemli farklılıklar göstermekle birlikte, Reuters Eşleştirme Sistemi'nin genel olarak fiyat keşfinde lider olduğunu göstermektedir. Ayrıca, gösterge niteliğindeki kotasyonların bilgi liderliği paylarının döviz kurlarının

çoğunda en az %40'a ulaştığı görülmekte, bu da yeni bilginin yaklaşık %40'ının ilk olarak gösterge niteliğindeki kotasyonlara dahil olduğunu göstermektedir. Tahmin edilen fiyat keşfi ölçütleri arasındaki önemli farklılıklar, Putnins'in (2013) fiyat serilerindeki gürültünün farklı olması durumunda, bilgi ve bileşen payı ölçütlerinin yeni bilgi aktarımındaki liderlik ile gürültüden göreceli kaçınmanın bir kombinasyonunu değişen derecelerde ölçtüğünü savunan argümanını desteklemektedir. Bu bulgular, karşılaştırılan seriler arasında farklı derecelerde gürültü olduğunda fiyat keşfi ölçütünün seçiminin önemini vurgulamaktadır. Bu çalışma aynı zamanda fiyat keşfinin belirleyicilerini de ortaya çıkarmakta ve alış-satış farkı oranı, kotasyon sayısı oranı ve oynaklık oranının gösterge ve işlem yapılabilir kotasyonlar arasındaki fiyat keşfini etkileyen önemli piyasa değişkenleri olduğunu ortaya koymaktadır.

Özetle, bu tez çalışması, işlem yapılabilir/kesin kotasyonlar ile gösterge niteliğindeki kotasyonların detaylı bir karşılaştırmasını sunarak döviz piyasasındaki fiyat keşfinin daha iyi anlaşılmasına katkı sağlamaktadır. Bulgular, döviz piyasasında fiyat keşfi açısından oynaklığın, alım satım faaliyetlerinin ve alış-satış farklarının önemini vurgulamaktadır. Ayrıca, çalışmanın bulguları farklı piyasa ortamlarına uygun fiyat keşfi ölçütünün seçilmesinin önemini altını çizmektedir. Araştırma aynı zamanda akademik yazındaki önceki çelişkileri gidermekte ve merkezi olmayan piyasalarda fiyat keşfinin gelişen dinamiklerini keşfetmek için gelecekteki çalışmalara zemin hazırlamaktadır.

Bu çalışmanın bulgularının düzenleyiciler ve merkez bankaları için de önemli politika çıkarımlarına sahip olduğu düşünülmektedir. Düzenleyicilerin önemli bir rolü, piyasaların düzenli işleyişi için piyasa izleme ve gözetimidir. Bu kapsamda, çalışmanın bulguları, piyasanın tam ve detaylı resmini elde etmek için sadece büyük işlem platformlarından değil aynı zamanda gösterge niteliğindeki kotasyonlardan elde edilen piyasa fiyatlarını izlemenin de önemli olduğunu vurgulamaktadır. Ayrıca, politika yapımcıların fiyat keşfi sürecinde aktif işlem piyasalarının (Londra, New York vb.) etkisini dikkate alması ve temel finans merkezleri kapalıyken gösterge niteliğindeki kotasyonlara daha fazla odaklanmasının faydalı olacağı

değerlendirilmektedir. Bu çalışmanın sonuçlarının merkez bankalarının döviz piyasası müdahaleleri açısından da önemli çıkarımları bulunduğu düşünülmektedir. Bulgular, fiyat keşfinin yoğunlukla birincil işlem platformlarında gerçekleştiğini ve alış-satış farklarının bu platformdaki fiyat keşfi ile pozitif ilişkili olduğunu gösterdiğinden, merkez bankalarının döviz piyasasına müdahale ederken belirgin bir fiyat etkisi yaratmayı ve müdahale yapıldığı bilgisinin bilinmesini amaçladıklarında, müdahaleyi birincil işlem platformları kullanarak yapmalarının uygun olacağı düşünülmektedir. Öte yandan, müdahale bilgisinin gizli kalmasının tercih edilmesi durumunda, birden fazla piyasa oyuncusunu kullanılarak müdahale yapılmasının ve birincil işlem platformlarının kullanılmamasının uygun olacağı değerlendirilmektedir.



D. THESIS PERMISSION FORM / TEZ İZİN FORMU

ENSTİTÜ / INSTITUTE

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