THE SPREAD COMPONENT OF THE EXCHANGE RATE: THE INDONESIAN CASE

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A b s t r a k s i

Paper ini menganalisa perilaku trader *yang merupakan isu utama didalam* market microstucture*, karena perilaku ini dapat mempengaruhi inefisiensi pasar. Perilaku ini menetukan* bid-ask spread *yang komponennya terdiri dari* order-processing cost, adverse selection cost *dan* inventory holding cost. *Dengan mengetahui perilaku* trader *dalam menentukan* spread*, kita akan mengetahui perilaku perubahan nilai tukar dalam jangka pendek, dimana hal ini sangat penting bagi pelaku pasar didalam menjalankan bisnisnya.*

Dengan menggunakan nilai tukar Rupiah terhadap US dollar, diketahui bahwa order processing cost *adalah komponen spread yang paling kecil. Hal ini tidak mengejutkan karena pasar valuta asing merupakan pasar yang sangat kompetitif. Sedangkan porsi terbesar dari komponen spread adalah* inventory holding cost*, hal ini disebabkan karena adanya* opportunity cost *dan resiko perubahan kurs.* Adverse selection cost *adalah komponen spread terpenting kedua. Hal ini dikarenakan Bank Indonesia melakukan intervensi secara diam-diam terhadap pasar valuta asing, jika tidak maka* trader *akan mendapatkan informasi yang sama tentang kebijakan pemerintah atau perilaku dari makro ekonomi sebuah negara.*

Keywords: Foreign exchange, spread, order-processing cost, adverse selection cost, inventory holding cost.

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I. INTRODUCTION

The study of securities market microstructure deals with the behavior of market participants in securities markets, the information effects and institutional rules of those markets, (Flood, 1991 p.52). This paper focuses on the behavior of market agents and market characteristics rather than on the influence of macro fundamentals.

The market participant behavior has an impact on the market inefficiency. Moreover, the interaction of institutional and behavioral factors generates the bid-ask spread. Bid is the buying price (from market maker's point of view), and ask is the selling price (from the same point of view). The spread is the difference between the ask price and bid price.

Dealer always shifts the quotes after buying and/ or selling a currency. This meant that the dealer was most concerned with the inventory cost since holding a currency inventory to provide immediacy imposes opportunity costs and the risk of changes in inventory value. The next question is how important is the inventory cost as component of the bid-ask spreads. Employing the hard currencies (US, Deutsche Mark, and Japanese Yen) data, we found that the inventory cost is the most importance component (Danila, 2000). However, it might be not the case when we use soft currency, namely Indonesia rupiah. By recognizing the behavior of the traders in quoting the bid and ask prices, we will observe the behavior of exchange rate in the short-run, which is very important for the market players who deal with it in their business.

This paper is organized as follows: the theoretical background will be developed in the next section, followed by the discussion of the empirical analysis.

II. THEORY

II.1. The Concept

As mentioned in the previous section that the interaction of institutional and behavioral factors generates the bid-ask spread. Quoted prices are different from transaction prices. Quotes are only indicative; they do not represent the bid and ask prices at which a bank will enter into a transaction. The trade activity within the inter-bank market is different from the posting of indicative quotes. However, the trading and quote-making decisions are not made independently from one another (Evans, 1998).

Flood (1991, p.64) argues that the bid-ask spread violates the law of one price, since it prices the same commodity differently. However, there are several reasons to explain this apparent inconsistency. We argue in the next section that the bid-ask spread covers three types of costs:

order-processing costs, asymmetric-information costs, and inventory carrying costs (Bessembinder, 1994 p.322).

In the foreign exchange market, market makers do not act as brokers, and the brokers do not act as market makers. They have separate functions. Market makers determine the bid and ask spread, and brokers just receive the bid price (limit orders) from market makers and the ask price (limit orders) from other market makers. The broker's spread is the combination of the best bid and best ask, received by a broker as separate limit orders. "One motive for trading through a foreign exchange broker is to maintain anonymity-the name of the bank placing a limit order is not revealed unless a deal is consummated and then only to the counterparty" (Flood, 1991 p.67). However, the theoretical models of brokered spreads are few, and there is not a clear understanding of the differences in price information between a market maker's spread and a broker's spread.

Market microstructure classifies a market as an inter-bank direct market (decentralized, continuous, open bid, double-auction market), or a brokered market (quasi-centralized, continuous, limit book, single-auction market)(Flood, 1991). The concepts are defined as follows:

- A *decentralized* market is one in which market makers (banks) quote and transact privately. Thus, the price is quoted and the transaction is done by a private meeting between two market makers (banks). A *quasi-centralized* market is one in which brokers accumulate a subset of market makers' limit orders. The market is not fully centralized, since there is a multiplicity of brokers in the foreign exchange market, and, each broker receives a subset of market maker's limit orders.
- *A continuous* market is when "trading occurs at its own pace, and transaction orders are processed as they arrive" (Flood, 1991 p.58). With continuous trading, earlier transactions satisfy some consumers and producers, and this causes shifts in supply and demand that affect prices for later transactions.
- *"Open-bid"* and *"limit-book"* are the ways of communicating price information. "Open-bid" is when a buy or sell price is announced to all agents in the market. Any participant can contact a market maker at any time for a price quote. "Limit-book" refers to the book of market maker's limit orders that contains an order to buy or sell a specified quantity of foreign currency at a specified price. The brokers arrange trades by keeping this limit book from which they quote the best bid and ask orders upon request. They refer to the best bid and ask in this book as the inside spread. Thus, the market makers can contact brokers to obtain the inside spread.
- *"Double-auction"* and *"single-auction"* are the ways the prices are quoted. Double-auction occurs when prices of both bid and ask are provided by participants, while a single-auction

is when prices are specified either to buy or sell. Hence, market makers provide double-auction prices, and brokers collect single-auction quotes in both ways, bid and ask quotes.

We now consider the important aspect of spread, that is the components of spread.

II.2. The Components of Bid-Ask Spread

As mentioned above, the spread covers three costs: order-processing costs, asymmetric-information cost and inventory carrying costs.

The order processing cost is a compensation for the costs of the transactions (telephone and telex charges, salaries, etc.). Glassman (1987 p.487) predicts that transaction costs may decline monotonically over time as technology in communications improve, as the volume of transactions became larger, and with an increase in competition among market makers. Empirically, so far, there has been no tendency for transaction costs to decline: instead they have varied from year to year. Glassman believes these changes can be explained by changes in government controls on the foreign exchange and capital markets.

The asymmetric-information cost (the cost of adverse selection) is explained as the compensation to market participants for losing to the "information-motivated traders". Bagehot (1971) suggests that market makers deal with liquidity-motivated transactors who pay the spread in exchange for the service of predictable immediacy and with traders who have inside information. Thus, the market makers must charge everyone a wider spread to compensate for their loss when trading with informed traders. Informed traders are potentially able to obtain short-term profit from their own customers' orders who are liquidity-based since the informed traders can identify their customers who trade due to financing international trade or corporate transactions from the customers who have superior information regarding the fundamental determinants of the spot exchange rate. Thus, the liquidity traders' strategies are designed to minimize losses when dealing with informed traders (Lyons, 1997).

Glosten and Milgrom (1985) develop a model to show how the spread arises from adverse selection. Their model uses a risk-neutral competitive specialist who faces no transaction costs, that is, a specialist who has unlimited inventories of cash and securities with which to transact and the holding cost of inventories is zero. The ask prices increase and bid prices decrease if the insiders' information becomes better, or the insiders become more numerous relative to liquidity traders, or the elasticity of the expected supply and demand of a liquidity trader increases.

Chung and Charvenwong (1998, p.1) also suggest that the market makers protect themselves from the informed traders by maintaining larger spreads for stocks with a greater

tendency of insider trading since they may not able to detect the insider trading when it occurs. Furthermore, Glosten and Milgrom state that the spread from adverse selection and from specialists' costs have a qualitatively different effect on the serial correlation of price changes. The spread from specialists' cost leads to negative serial correlation, while spreads due solely to adverse selection do not lead to serial correlation. Then, the correlation coefficient can be used to determine the relative magnitudes of the sources of the spread. In addition, over time, the value expectations of the specialist and the insiders tend to converge. It means the insider information tends to be fully disseminated into the market prices.

Glosten (1987) explores further the relation between bid-ask spreads and transaction price behavior by focusing on asymmetric information and gross profit components of the spread. He supports the Glosten and Milgrom (1985) results: the spread from the gross profit components source induces biases in the measurement of mean return and variances of the return, and that induces negative serial covariance in the measured returns. The gross profit component leads to a fluctuation in transaction prices about the true price, while the adverse selection component leads only to fluctuations in the true price.

To follow up Glosten's model (1985 and 1987), Glosten and Harris (1988) develop and implement a technique for estimating a model of the bid-ask spread. They decompose the spread into two components: due to asymmetry, and due to inventory costs, specialist monopoly power, and clearing costs. They use NYSE common stock transaction prices in the period 1981-1983. They call the inventory cost, clearing fees, and/or monopoly profits the transitory component, since its effect on stock price time series is unrelated to the underlying value of the securities.

In contrast, they call the adverse selection component the permanent component, since it has a permanent effect on all future prices due to the revision of market maker expectations. They conclude that there is evidence of adverse selection in the components of spread. The adverse selection spread component should be positively related to transitory spread component. The wider the transitory spread, the more likely liquidity motivates the trader's trade. When the transitory spread is small, the number of informed trader should increase, and the adverse selection should also increase.

In the foreign exchange market, Ito, et al (1998) defines private information as information that satisfies two criteria: (1) it is not common knowledge, and (2) it is price relevant. They provide a taxonomy of private information by considering a two-period trading model in which trading occurs at prices P_0 and P_1, then a terminal payoff F is realized at t=2. They refer to information on the terminal payoff F as fundamental private information, e.g. a dealer who

receives private signals of a country's trade balance long before published statistics are available and a dealer who receives a central bank's order has also received private information. The latter is part of "secret" government intervention: the Fed intervenes secretly through the broker market, or through a commercial bank with which it does not usually do business. The broker or the bank has an incentive not to disclose this intervention if it wants to be privy to future intervention and business (Frenkel and Dominguez, 1993).

In contrast, the information unrelated to the payoff *F* but relevant to interim prices P_0 and P_1 is considered to be semi fundamental private information. Ito, et al (1998) provide two examples in order to describe semi fundamental private information. The first example is superior knowledge of the distribution of dealer inventories. Because the transparency of order flow in spot foreign exchange is low, a dealer often has superior knowledge of her own and others' inventories.

Moreover, Lyons (1993) confirms that the foreign exchange market is a phone and computer network over which dealers quote bid and ask prices, and then consummate transactions. These communications are purely bilateral, so that the price and quantities traded are not transparent as they are in other financial markets. He says that asymmetric information occurs if a market maker deals with a non-market maker customer and other market makers do not know about it. Thus, he concludes that order flow as the source of information asymmetry among dealers (Lyons, 1991).

A second example is when traders share common information on *F* but they may still disagree on the meaning of this information, thereby affecting P_0 or P_1. Then, Ito, et al. (1998) provide evidence of private information in the foreign exchange market as he wrote; "Lunch-return variance doubles with the introduction for trading, which cannot be due to public information since the flow of public information did not change with the trading rules" (p.1111).

Flood (1991 p.65) also says that the adverse selection applies in the foreign exchange market, since the spread allows market makers some protection against arbitrage opportunities. Arbitrage opportunities are viewed as a form of inside information in a market where price information is not centralized. In addition, Bessembinder (1994) suggests that adverse selection (informed traders[1]) exists in the foreign exchange market even though the potential loss from informed traders is less than it is in the equity market.

Bossaerts and Hillion (1991) investigate the bid-ask spread in the spot and forward foreign exchange markets when some traders have superior information about government intervention

1 Uninformed traders (liquidity traders) are traders who trade but not because of the superior information they have.

using four continental European currencies with respect to the French franc. They observe that higher and asymmetric bid-ask spreads on Fridays reflect the market makers' reaction when they are confronted with the better-informed traders. The smaller and less asymmetric spreads on other days of the week than Fridays suggest that the superior information has value beyond one day, up to a whole week. They also find that there is a less volatile risk premium using currencies with respect to the French franc than currencies with respect to the U.S. dollar. It means that there is a different degree of uncertainty about government intervention. Higher uncertainty about the intervention will increase the asymmetry of the spreads. It makes the forward rate more biased as a predictor of the future spot rate (Bossaerts and Hilton, 1991, p.539).

Like others central banks, Bank Indonesia (BI) intervenes in the market to maintain exchange rate stability. BI intervenes in the market when there is indication of high volatility. The amount, strategy and timing of intervention are kept secretly by Bank Indonesia. Moreover, BI chooses spot transaction in conducting its intervention due to several reasons, namely:

- The huge volume of transaction which reflect the volatility of rupiah
- The potential influence of price movement
- The pattern of speculative behavior is reflected in spot market

BI has two methods in conducting the intervention; those are open method and closed method. Open method is when intervention conducted directly to the market, while close method is when intervention conducted through agent (intermediary). In choosing types of intervention depends on several conditions: whether BI wants the market know clearly about intervention, supply and demand of dollar, development of market sentiment, and result of technical analysis (BIS paper no.24, May, 2005).

The inventory carrying cost relates to an opportunity cost component and the risk of changes in inventory value (Bessembinder, 1994). The opportunity cost occurs because the interest rate that can be earned for holding currency inventory that is needed for the spot market is less than the interest rates that can be earned on less liquid deposits. This cost is also referred to as the risk component (Glassman, 1987, p.479). The inventory carrying cost (risk component) increases before weekends and holidays due to the increase of the opportunity cost and the risk of the probability of an exchange rate change that will affect the value of inventory. It will widen the spreads, thus the currency bid-ask spreads widen with an increase of inventory carrying cost (Bessembinder, 1994 p.331; Glassman, 1987 p.486). Furthermore, the risk component of spreads appears to be influenced by the rate of transactions in the market that is measured by trading volume and the volatility of prices.

II.3. Factors that Influence the Bid-Ask Spread

Based on the previous writings, we argue that there are three factors that influence the bid-ask spread: price volatility, the market's anticipation of price volatility, and trading volume. There is a positive relation between the spread and price volatility. Many findings support this relation. Boothe (1988, p.485) shows the evidence of a relation between exchange rate uncertainty (volatility) and the size of transaction costs (bid-ask spreads) for seven currencies. Bessembinder (1994) and Glassman (1987) also support this argument. In addition, bid-ask spreads have been found to be wider under floating exchange rates than under fixed (Aliber, 1975; IMF Annual report, 1982).

The second factor is the market's anticipation of volatility. Wei (1994) uses a currency option to measure the market's ex ante estimation of exchange rate volatility. "The implied standard deviation from options can be thought of as a market's anticipation of the average daily volatility over the lifetime of the contract" (Wei, 1994 p.9). He finds that a one percent increase in anticipated volatility will widen the bid-ask spreads as much as 0.015%.

The third factor is trading volume. Glassman (1987 p.486) finds that there is positive relation between trading volume and spreads. It can be explained by the amount of trader disagreement[2]. This finding is defended by Wei (1994, p.19). He argues that a one percent increase in trading volume leads to a widening of the spread by approximately 0.005% point. Furthermore, Glassman (1987) finds the same result as Wei, even though the estimate of the effect of the volume appears much less than the estimates obtained by Wei. Black (1991 p. 514), however, argues that spreads vary inversely with the expected volume of transactions in the market. Thus the spreads will widen as the volume decreases. Bessembinder (1994 p.329) decomposes volume as forecastable volume and unforecastable volume, and finds that forecastable and unforecastable volumes have different effects on bid-ask spread. Bid-ask spreads decrease when forecastable volume increases, and bid-ask spreads increase when unforecastable volume increases.

Research by Lyons (1993) finds trading volume also causes price movement through an inventory channel and an information channel. Information asymmetry induces a price increase of one pip[3] for every US$10 million purchase at quoted prices (against DM). Prices can move through the inventory channel by lowering (raising/appreciating) quoted DM price by 3/4 of

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2 There are three determinants of trading volume: (1) the rate of information flows, (2) the amount of trader disagreement, and (3)the number of active traders. Point (2) is relatively more important than (3) for the foreign exchange market, while the literature suggests that (3) is relatively more important for securities markets (Glassman, 1987, p.486).

3 Foreign exchange dealer's term for 0.00001 of a unit, e.g.: if the $/yen rate is quoted 220.20 then a rise of five pipe would yield 220.25.

one pip for every US$10 million of a long position in dollars to motivate dollar purchases (to unload undesired inventory).

Bollerslev and Domowitz (1993) find a strong relation between trading activity (quote arrivals) and bid-ask spreads but only for small banks. The authors conjecture this occurs because small banks have less information regarding retail order flow at the open hour. Thus the spreads might be higher at this time, and they will widen the quoted spreads as trading activity increases. In addition, small banks generate quoted arrivals only during business hours. Hence they are more concerned with their positions at the closing hour. In general, all banks seek to reduce foreign currency positions and increase dollar positions by reducing the quotes on Fridays (before weekends). Thus foreign currencies tend to depreciate against the dollar on weekends (Bessembinder, 1994 p.346).

II.4. The Volatility of Exchange Rates

After the Bretton Woods System collapsed in 1971-1973, many countries moved to flexible exchange rates and exchange rates became more volatile. Market participants compare the observed exchange rates with expected exchange rate changes. Interest parity theory implies that "the forward premium is the best available forecast of the future change in the exchange rates" (DeGrauwe, 1989 p.60). However, in the real world changes in the observed exchange rates are much larger than the expected changes measured by forward premia. Therefore DeGrauwe concludes that the forward premia or discounts do not forecast the size and the direction of a high degree of exchange rate movements.

Another benchmark to measure the nature of exchange rate volatility has been Purchasing Power Parity (PPP). This theory says the equilibrium exchange rate is determined by the ratio of the domestic and the foreign price level. But, again, observed exchange rates have moved much more than Purchasing Power Parity rates[4] . In other words, there is strong correlation of the nominal and the real exchange rates as the nominal exchange rates vary much more than national price levels (DeGrauwe, 1989).

Tae-Hwy Lee (1994) uses the spread between spot and forward exchange rates to predict the volatility of exchange rate changes. There is evidence that spot and forward exchange rates are strongly cointegrated, that is, there is a long-term equilibrium relationship between spot and forward exchange rates. Furthermore, it seems that the larger the spread between spot and forward rates, the more volatile and uncertain the exchange rates. The volatility can

4 See Pilbeam, Keith, *International Finance*, Macmillan, London, second edition, 1998.

also be seen from the trading patterns in exchange rate markets. London and New York markets have U-shaped trading patterns, that is busy trade exists at the opening and closing of the market. It appears to be same as in the Tokyo market but it is much less busy. This U-shape trading pattern might be explained by a systematic release of news. Overall, the US market is the most volatile, followed by European then Asian markets (Baillie and Bollerslev, 1990; Bollerslev and Domowitz, 1993). Evans (1998) also examines the trading patterns of volatility in Deutsche mark market using quotes and transactions prices data. He comes to the same conclusion, i.e., some evidence of a U-shape trading pattern, even though the seasonal pattern of transaction prices is more pronounced than in the quote data.

Furthermore Goodhart and Figliuoli (1991) suggest that foreign exchange spot rates (in ultra high frequency minute-by-minute data) show a unit root, significant first-order negative correlation, mild heterocedasticity during quiet periods (more significant during disturbed market conditions), and a tendency towards inefficiency. Goodhart (1988) also says: "first, apart from ultra-high-frequency hourly data, where there are some signs of overshooting, it is hard to see any obvious signs of 'overshooting', either in the time-series patterns, or in the reactions to major UK news events or (unanticipated) interest rate changes. Instead, the exchange rate in the short run appears, if anything, to be characterized by some slight persistence and inertia; second, it often remains misaligned for long periods, in the sense that the forces driving it back to a long-term equilibrium are notably weak; third, there is virtually no information contained in the pattern of forward rates" (p.446-447).

What are the sources of the volatility? According to De Grauwe, in flexible exchange rate systems the volatility is determined by the expectations agents hold about the future. Fundamental variables (such as price levels, interest rates, current account, or other economic variables) and irrelevant variables influence the agents' expectations.

Different types of agents have different ways of forming expectations. There are three types of agents who influence the volatility (fluctuations) of the exchange rate: noise traders (chartists), fundamentalists, and rational speculators. They have different impacts on any volatility which is triggered by a random shock to the market. Noise traders are investors whose demand for currencies is influenced by beliefs or sentiments that are not fully consistent with economic fundamentals (Hung, 1997,p.781). Many noise traders are chartists. Chartists are market participants who have extrapolative expectations, i.e. they compare the current change in the exchange rate with the change in the previous period. "Some chartists use moving averages of exchange rates of different periods to generate buying or selling signals, while other use trendlines to clarify the direction of market movements" (p.781).

Fundamentalists are market participants who have regressive expectations. They assume that the exchange rate will finally move towards a perceived equilibrium value based on macroeconomics movements, which are congruent with exchange rate determination. Rational speculators are market participants who notice the changes of the exchange rate stimulated by the behavior of chartists and fundamentalists. Thus, the difference between the expected exchange rate next period and the current exchange rate determines their demand for foreign exchange (Frenkel, 1996).

How do the different groups affect the volatility of the exchange rate when there is a random shock to the market? Assume that the equilibrium of the exchange rate is initially at the level determined by fundamentals. When there is a random shock, chartists induce fluctuations around the initial equilibrium. The fluctuations depend on the values of the demand elasticity of the exchange rate. The fluctuations can be converging, constant, or diverging. The fluctuation will be converging if the demand elasticity is less than one. A constant fluctuation is the result of the demand elasticity being equal to one, while diverging volatility exists when the demand elasticity is more than one (Frenkel, 1997).

There is a different story when fundamentalists enter the market. They reduce the volatility of the exchange rate, with the assumption that they recognise the long-run exchange rate. The higher the ratio of fundamentalists to speculators, the lower is the volatility of exchange rate. On the other hand, if fundamentalists do not know the long-run exchange rate, the more often fundamentalists revise their beliefs about the future time path of fundamental, the more volatile is the exchange rate.

Finally, the presence of rational speculators further discourages fluctuations in the exchange rate as long as the speculators correctly anticipate the beliefs of fundamentalists, the actual development of fundamentals is not different from the expected value, and random shocks do not occur (Frenkel, 1997).

Another source of volatility is news. Melvin and Yin (1996) find the rate of information arrival at the market fluctuates positively with the volatility of the mark/dollar exchange rate, and public information plays an important role in the evolution of the foreign exchange market. Furthermore, Baillie and Bollerslev (1990) detect autocorrelation in news which is consistent with a "heat-wave" type, that is a high (low) volatility today at a certain hour is likely to increase (decrease) the volatility at the same time the following day. The heat-wave contrasts with a "meteor shower", that is transmission of news through time and across different market locations. MacDonald and Marsh (1996) also suggest that "informational asymmetries between nations are small and that it is appropriate to think of a global foreign exchange market with a

common information set" (p.669). The source of a meteor shower is the heterogeneous expectations of market participants. New information causes exchange rates to change but does not necessarily lead to an increase in exchange rate volatility around the world (Hogan and Melvin, 1994).

II.5. Price changes Due to the Spread

The theories about spreads are theories of "quoted" spreads, that is the difference between the ask price quoted by market maker and the bid price quoted by market maker. "Realized" spreads are the difference between the ask price at which a market maker makes a transaction and the bid price at which a market maker makes a transaction (Stoll, 1989). The quoted spreads are not necessarily the same as realized spreads. In the theory quoted spread covers order-processing cost, adverse selection cost, and inventory holding cost.

According to Stoll (1989) there are three alternative views of the trading process with an assumption of no new information: the only information is revealed by the transaction itself and the spread is constant.

1) If the spread reflects only order processing costs, the ask (A) and the bid price (B) always straddles the "true" price. The market maker covers costs by buying at B_0 and selling at A_1 (on average)[5] . Sequences of purchases at the bid price are ultimately offset by sequences of sales at the ask price. The realized spread, $A_1 - B_0$, is the same as the quoted spread, $A_0 - B_0$.
2) If the spread reflects inventory holding costs, the marker maker will change the position of the spread relative to the "true" price in order to induce the transactions that will unload undesired inventory. For example, after a market maker purchase the market maker will lower the bid and the ask price. The purpose is to motivate market maker sales (the ask price is lower) and to inhibit additional market maker purchases (the bid price is lower). Bessembinder (1994, p.339) confirms this view: "one method of decreasing a currency position is to decrease quotes in relation to value to increase the likelihood of customer purchases and decrease the likelihood of customer sales. Altering positions by shading quotes allows the bank to continue earning a spread on transactions". In addition, Wei (1994, p.5) says that a market maker can only change the quotes after some transactions. In this case, under a linear inventory cost assumption, the spread is twice the inventory cost of a transaction (buy and sell). If the market maker buys, the inventory will be larger by one transaction amount. The bid price will be lower by -0.5S (where S is spread), and the ask price will be

5 0 means previous time, while 1 means the later time.

lower by 0.5S. If the next transaction is the reversal transaction (sell) the market maker will get a lower price (0.5S). Thus, the realized spread, $(A_1 - B_0)$, is smaller than the quoted spread.

3) If the spread reflects the adverse information costs, the prices will move like the inventory holding cost, but under adverse selection there is a different reason. After a market maker purchase, bid and ask prices are lowered because a transaction at B_0 conveys information that the expected equilibrium price of the exchange rate is lower. Such information is conveyed under the assumption that some traders have superior information. Thus, the realized spread, $(A_1 - B_0)$, is smaller than the quoted spread.

Stoll (1989) summarises the three views by the values of two parameters, θ and π. The size of a price reversal is given by $(1-\theta)S$, where S is the spread and $0 \leq \theta \leq 1$. The probability of a price reversal is π. The price continuation is θS and the probability of a continuation is $(1-\pi)$. Price reversals are assumed to be symmetric in the sense that a price increase after a transaction at the ask has the same size as a price decrease after a transaction at the bid. Price continuations are assumed to be symmetric in the same way.

- Under pure order processing, the amount of price continuation (θ) is 0 because the price reversal $(1-\theta)$ is equal to the spread. The probability of price reversal (π) is 0.5, because prices simply move between the bid and the ask.
- Under pure inventory holding cost, the amount of price reversal $(1-\theta)$ is 0.5 and the probability of price reversal (π) exceeds 0.5 because the dealer wants to modify a transaction in one direction or the other.
- Under pure adverse selection, the amount of price reversal $(1-\theta)$ is 0.5 and is equal to the price continuation. The probability of price reversal (π) is 0.5 because of the equilibrium price change. Thus, the dealer is indifferent whether the next trade is the same as the last trade or the opposite.

Stoll (1989) develops his model under three assumptions:

1. The market is informationally efficient in the sense that the expected price change in a security is independent of current and past information. In the foreign exchange market, the market appears to be efficient since only unexpected changes in money supply lead to changes in exchange rates, and the exchange rate responses are rapid, often completed within twenty minutes of the announcement (Hakkio and Pearce, 1985).
2. The spread, *S*, is constant over the period for which empirical work is carried out. In the foreign exchange market, the spread is clustered at the value of 10 for 53% of the quotations (Bessembinder, 1994; Goodhart, 1991). Thus, this assumption can be applied to the foreign exchange market.

3. All transactions are carried out at the highest bid or the lowest ask price available in the market.

The total price change in a security may then be decomposed into three components (Stoll, 1989)[6]:

$$\Delta V_t = a + \Delta P_t + e_t$$

where,

ΔV_t = total price change in a security between time t - 1 and time t
a = expected price change in the security in the absence of the bid-ask spread
ΔP_t = price change due to the spread, and
e_t = price change due to new information; $E(e_t) = 0$

Then

$$cov(\Delta V_t, \Delta V_{t+1}) = cov(\Delta P_t, \Delta P_{t+1}) + cov(\Delta P_t, e_{t+1}) + cov(e_t, \Delta P_{t+1}) + cov(e_t, e_{t+1})$$

In an efficient market, changes in prices due to new information are serially uncorrelated and are uncorrelated with lagged or leading values of the price change due to the spread. Then

$$cov(\Delta V_t, \Delta V_{t+1}) = cov(\Delta P_t, \Delta P_{t+1})$$

Under the assumption of constant spread, the possible price changes DP_t, starting at the bid price (Stoll, 1989), are

$$\Delta P_t = (A_t - B_{t-1}) = (1 - \theta)S \quad \text{with } prob\ \pi,$$
$$(B_t - B_{t-1}) = -\theta S \quad \text{with } prob\ (1 - \pi)$$

Under the assumption of symmetry, the possible price changes starting at the ask prices (Stoll,1989)are

$$\Delta P_t = (B_t - A_{t-1}) = -(1 - \theta)S \quad \text{with } prob\ \pi,$$
$$(A_t - A_{t-1}) = \theta S \quad \text{with } prob\ (1 - \pi)$$

Transactions at time t-1 are assumed to occur with equal probability at the bid or ask.

The expected price change conditional on a transaction at the bid is

$$E(\Delta P_t | B_{t-1}) = \pi(1 - \theta)S + (1 - \pi)(-\theta S) = (\pi - \theta)S$$

The expected price change conditional on a transaction at the ask is

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6 Roll (1984) also models the bid-ask spread estimator for financial securities. Moreover, Bhardwaj and Moore (1998) modify the Roll's (1984) model by using spread estimator developed directly for a correlated value innovation process. We do not describe Roll's (1984) model in this thesis since we use Stoll's (1989) model.

$$E(\Delta P_t \mid A_{t-1}) = -(1 - \theta)S\pi + (1 - \pi)\theta S = -(\pi - \theta)S$$

The realized spread is the expected price change after a dealer purchase less the expected price change after a dealer sale, that is $2(\pi - \theta)S$. Given an equal probability of a transaction at the ask and the bid, the unconditional expected price change is $E(\Delta P_t) = 0$ (Stoll, p121). The realized spread is the expected revenue on two transactions: a purchase and a sale.

Under pure order-processing cost, the realized spread is equal to quoted spread ($\pi = 0.5$, $\theta = 0$). Under pure adverse information, the realized spread is zero ($\pi = 0.5$, $\theta = 0.5$). Under pure inventory holding cost, the realized spread is positive but less than quoted spread ($\pi > 0.5$, $\theta = 0.5$).

The serial covariance depends on the two-period (three-date) sequence of prices. If a transaction at the bid is followed by another transaction at the bid (a continuation), the price change is $-\theta S$, where $0 < \theta < 1$. If a transaction at the bid is followed by a transaction at the ask, the price change is $(1 - \theta)S$, a reversal. The probability of a continuation is $(1 - \pi)$, and the probability of a reversal is π. Under the assumption of constant spread, the difference in price changes is always equal to the spread, S.

The serial covariance of transaction price changes is (Stoll, 1989):

$$cov_T = cov\,(\Delta P_t, \Delta P_{t+1}) = S^2[\theta^2(1 - 2\pi) - \pi^2(1 - 2\theta)]$$

The serial covariance of quoted price changes is:

$$cov_B = cov\,(\Delta B_t, \Delta B_{t+1}) = \theta^2\, S^2(1 - 2\pi)$$

$$cov_A = cov\,(\Delta A_t, \Delta A_{t+1}) = \theta^2\, S^2(1 - 2\pi)$$

Equations above can be written in a regression framework as

$$cov_T = a_0 + a_1\, S^2 + u$$

$$cov_Q = b_0 + b_1\, S^2 + v\ ,$$

where u,v are random errors

$$a_1 = \theta^2(1 - 2\pi) - \pi^2(1 - 2\theta)$$

$$b_1 = \theta^2(1 - 2\pi)$$

We can explain the decomposition of the quoted spread according to order costs, inventory holding cost, and adverse information cost with the following methodology.

We will use simple regression for estimating the value of covariance transaction price and quoted price. To infer the relative importance of bid-ask spread components, we take several steps as follows:

- After obtaining coefficient a_1 and b_1, we calculate the value of π and θ. Then we will get the realized spread value by substituting the value of π and θ into realized spread formula: $2(\pi - \theta)S$.
- As noted before, the adverse information cost has zero realized spread. It means the expected revenue per trade is zero. Thus, the adverse information cost component of the quoted spread is the difference between the quoted spread and the realized spread. Therefore, the realized spread only consists of the order-processing cost and the inventory holding cost.
- Derivation of the order-processing cost and inventory holding cost components requires a division of the realized spread. We will divide the realized spread using the observed value π and the value θ: 0.5 for inventory holding cost and 0 for order-processing cost.

Then, the relative importance of bid-ask spread components is obtained. The sources of data and empirical procedures are reviewed in the following section.

III. METHODOLOGY

III.1. Data

The data have been obtained from Central Bank of Indonesia[7], Bank Indonesia. The currency used is the Indonesia rupiah (Rp) against US dollar (USD) according to Reuters, Bloomberg and Bank Indonesia. The data contain date, bid, and ask at closing rate. The date is from 1 January 2006 to 20 November 2007 (excluding week ends). Due to the difficulty of obtaining the transaction data, we use two assumptions to proceed with the analysis. The assumptions are:

- The dealers make transactions every time they quote the bid and ask rate. The reason behind this assumption is that theory suggests that after buying or selling, the dealers will change the quotation (Stoll, 1989; Bessembinder, 1994; Wei, 1994). Evans (1998) also suggests "changes in trading activity within the interbank market significantly affect quotes while innovation in quote activity affect transactions" (p.4). Furthermore, an interview by the author with a dealer working in a large bank in Sydney, confirmed that the banks (dealers) change the bid-ask quote every time they make transactions.
- The transaction price is the mid-point of the bid and ask rate. The reason is that spreads in the market are inside spreads: the spread resulting from the combination of the lowest quoted ask and highest bid, which dealers are committed to trade (Goodhart and Payne, 1996). Moreover, Branch and Echevarria (1995, p.541) suggest that "a substantial number

7 Thanks to Bapak Rif'at Pasha who provides the data.

of last reported transactions for stocks trading on the New York Stock Exchange occur inside the quoted closing bid-ask spread". Thus, we use the mid-point of the bid and ask rate since the inside spreads are close to the mid-point value.

III.2. Empirical Procedure

To estimate the relative importance of the key forces believed to be acting on the bid-ask spread, we analyzed the data with the following steps:

- Calculate the bid-ask spread that is the proportional spread (spread divided by mid-point of bid and ask rate)
- Calculate the transaction price (mid-points bid and ask rate).
- Calculate the difference between day 2 and day 1 (as ΔPt+1), and the difference between day 1 and day 0 (as ΔPt) from 1 January 2006 to 20 November 2007.
- Calculate a covariance of ΔPt and ΔPt+1 based on 2, 3 and 5 working days. A reason using difference covariance is to check whether we will get similar results.
- Apply the same procedure to bid and ask.

The empirical model to be estimated are,

$$cov_T = a_0 + a_1 S^2 + u \text{ and}$$

$$cov_Q = b_0 + b_1 S^2 + v,$$

were cov_T is the covariance of transaction price; cov_Q is the covariance of bid or ask; S^2 is the squared value of the average proportional spread at closing time.

The next step is to use the point estimator to infer the components of the bid-ask spread. Because we have two values of b_1 (from cov_B and cov_A), we averaged them. We then calculated θ (price continuation) and π (the probability of price reversal) with the two equations:

$$a_1 = \theta^2(1 - 2\pi) - \pi^2(1 - 2\theta)$$

$$b_1 = \theta^2(1 - 2\pi)$$

As explained in previous section, the realized spread, $2(\pi - \theta)$, is the expected profit per transaction, while the realized spread comprises order processing costs and inventory holding costs. The realized spread is zero when the quoted spread is determined by adverse information (Stoll, 1989). Following Stoll, we derive the proportions of spread components by:

- $1 - 2(\pi - \theta)$ = adverse selection cost.
- $2(\pi - 0.5)$ = inventory holding cost.
- $1 - 2\theta$ = order processing cost.

IV. RESULT AND ANALYSIS

We estimate regressions using 2, 3 and 5 days covariance with and without a constant. A value of π and θ are shown in Table below.

Tabel IV.1
Reuters

	Cov-2 days	Cov-2 days no constant[8]	Cov-3 days	Cov-3 days no constant	Cov-5 days	Cov-5 days no constant
θ	0.50000	0.5009	0.5114	0.5084	0.5019	0.5027
π	0.6980	0.7211	0.2094	0.3452	0.7966	0.9025

Tabel IV.2
Bloomberg

	Cov-2 days	Cov-2 days no constant	Cov-3 days	Cov-3 days no constant	Cov-5 days	Cov-5 days no constant
θ	0.2680	-0.3158	0.4304	0.4733	0.1926	0.4571
π	-0.3626	0.2193	0.7320	0.9239	-0.2950	0.8014

Tabel IV.3
Bank Indonesia

	Cov-2 days	Cov-2 days no constant	Cov-3 days	Cov-3 days no constant	Cov-5 days	Cov-5 days no constant
θ	0.5470	0.6469	0.5319	0.2615	0.5203	0.2898
π	0.9645	0.5298	0.9805	-0.2747	0.9652	-0.3272

From the results above, we conclude that we can usefully estimate the three components of the bid-ask spread for the foreign exchange market. We now turn to examine the relative importance of bid-ask spread components.

8 It reflects the assumption of market efficiency in which the covariance induced by the spread is the only variable that causes the serial covariance price changes.

Tabel IV.4
Reuters

	Cov-2 days	Cov-2 days no constant	Cov-3 days	Cov-3 days no constant	Cov-5 days	Cov-5 days no constant
Adverse Selection cost	60%	44%	N/A	N/A	41%	20%
Inventory cost	40%	56%	N/A	N/A	59%	80%
Order-processing cost	0%	0%	N/A	N/A	0%	0%

Tabel IV.5
Bloomberg

	Cov-2 days	Cov-2 days no constant	Cov-3 days	Cov-3 days no constant	Cov-5 days	Cov-5 days no constant
Adverse Selection cost	N/A	N/A	40%	10%	N/A	31%
Inventory cost	N/A	N/A	46%	85%	N/A	60%
Order-processing cost	N/A	N/A	14%	5%	N/A	9%

Tabel IV.6
Bank Indonesia

	Cov-2 days	Cov-2 days no constant	Cov-3 days	Cov-3 days no constant	Cov-5 days	Cov-5 days no constant
Adverse Selection cost	N/A	N/A	10%	N/A	N/A	N/A
Inventory cost	N/A	N/A	90%	N/A	N/A	N/A
Order-processing cost	N/A	N/A	0%	N/A	N/A	N/A

From table IV.4, IV.5 and IV.6 above, we notice that the least important component in spread is the order-processing cost. The second[9] important is an adverse selection cost and the most important one is the inventory cost. This is consistent with Danila (2000) findings on hard currency[10] component's spread.

The smallest component of the bid-ask spread in the foreign exchange market appears to be order-processing cost. This is not a surprising finding because the foreign exchange market

9 Only Reuters with cov-2 days has opposite result that is the adverse selection cost is more important than the inventory cost
10 The currency used is Deutschemark against US dollar.

is a very competitive market (Flood, 1991; Goodhart and Figliuoli, 1991). Dealers seem to be mainly concerned with inventory cost and adverse selection cost. The second important component is inventory holding cost. This finding is relevant to the theory: because of the high volatility in the market, the inventory holding cost demands opportunity costs and the risk of changes in inventory value (Bessembinder, 1994). Moreover, Bollerslev and Domowitz (1993) concludes that small banks only quote during the regular business hours of their regional markets. Thus, they potentially have stronger inventory effect than larger banks, and so have more concern about their inventory positions at closing time. Moreover, smaller banks have less information based on retail order flow at the open time than larger banks that operate continuously.

Suvanto (1996) also noted that in the highly competitive and closely integrated foreign exchange market, the quotation of an individual dealer depends on the price quotes of others and it narrows the spread. Moreover, a dealer can easily unload the imbalance position by calling another market maker or he can make a very small price adjustment to attract orders from other dealers. This view is supported by Hsieh and Kleidon (1996). They observe that higher spread at the closing time can not be explained by standard information models, "the inventory management by market makers in the closing market appears to be the most likely explanation" (p.43). The reason is that although the dealer can easily trade away the unwanted inventory among traders during the most of the day, it is not true before the closing time. "Dealers who are already satisfied with their positions do not want new orders. Widening the spread decreases the likelihood of new orders. There may be unwanted open positions that do not find buyers until the spread is sufficiently large to make the price attractive to somebody, or sufficiently unattractive to the seller, until either of them is willing to carry an open overnight position" (Suvanto, 1996, p.69).

The overlapping time zones overcome this problem since the dealers in the closing time zone can trade away the unbalanced inventory to the dealers in open time zones (p.69). However, the levels of trading activity around hour 24 are very low (Bollerslev and Domowitz, 1993). The low trading activity decreases the ability to unload the imbalances across market makers. Thus, it increases the risk of changes in inventory value.

For smaller banks, there is an additional factor that contributes to a higher inventory holding cost. This is their lesser ability to trade away the imbalances across market makers since they operate mainly within regional markets with well defined market openings and closings (Bollerslev and Domowitz, 1993). Hsieh and Kleidon (1996, p.61) verify this opinion, noting that the smaller regional banks, who start and end the day with flat positions, have crucial inventory problems as the close of trading approaches.

Finally, adverse selection cost is the second important one. This finding is supported by Ito, et al (1998) who finds evidence of private information in the foreign exchange market.

In the foreign exchange market, it is impossible for traders to have a better knowledge of the future behavior of the macro economy of a country or international financial system (Lyons, 1993). However, it is possible for traders to have some inside information about the future government policy. Thus, adverse selection in the foreign exchange market is the "secret" government intervention, i.e. when the Federal Reserve intervenes in the market secretly through specific financial institutions rather than wholesale trading in the open market (Dominguez, 1993). In the case of Indonesia, "Bank Indonesia does not announce foreign currency intervention to the public, reserving to itself information regarding volume, strategy, and timing" (BIS paper no.24, May, 2005). It conforms our findings that the adverse selection cost is second important component in the spread. Overall, our findings of high inventory cost and adverse selection cost in foreign exchange market strengthen Lyons's notion of a strong information effect and a strong inventory-control effect in the spot foreign exchange market (Lyons, 1993).

V. CONCLUSION

In conclusion, the order-processing cost is the least important component of spread since the foreign exchange market is a very competitive market. The largest proportion of inventory holding cost in the spread component is due to holding currency as inventory imposes the opportunity costs and the risk of changes in inventory value in the high volatility market. Finally, the adverse selection cost is the second important component of spread in the foreign exchange markets. The reason is that in the foreign exchange market, the Bank Indonesia conducting intervention secretly. Otherwise traders will have the same information about the government policy or the behavior of the macro economy of a country.

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