Tunisian dealer behavior in FX market:Pricing decision

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Abstract

This paper attempts to models the pricing decision and order placement of a Tunisian foreign exchange dealer. The dataset for used is based on the complete records of a FX dealer at a Tunisian bank over the period 2 March 2000 to 28 November 2003 and for the Dollar (USD/TND) and the Euro (EUR/TND) daily exchange rates .

Using GMM estimation, we find we find support for information and inventory effects for the USD/TND, but no information and inventory effects for the EUR/TND.

Amongst all different types of order, the dealer's domestic order interbank is informative for the USD/TND. For foreign interbank orders, the orders are informatives. We find that dealer's demand widens with the information flow transmitted by the customer orders and are affected by the inventory control of the dealer. Our results indicate that the inclusion of TCB intervention seems to be significant only on the dealer's pricing decision for USD/TND.

Key words: FX Tunisian dealer; information, inventory, customer order, interbank order.

Contents

0.1 Introduction

The urgency development of microstructure theory on foreign exchange is largely motivated by the failure of macroeconomics models. So far, most microstructure research in foreign exchange focus is on bid-ask spread, volatility and heterogeneity issues. Only a few studies focus on testing market making behavior, because many datasets do not provide a direct measures of the volume traded or a dealer inventory. This information is considered as the property of the bank and is regarded as confidential information. However, this information allows to analyze the dealer's behavior, and, in particular to explain pricing decisions. The study of Lyons (1995) is the first one attempts to use the proprietary transaction data of a dealer for one week in August 1992.

This paper studies the pricing decisions of FX dealer who is subject to adverse selection arising from private information, and who has to manage his inventory. It uses a unique dataset of complete trade records for one Tunisian dealer from 02 March 2000 to 28 November 2003 and for the Dollar (USD/TND) and the Euro (EUR/TND) daily exchange rates.

The data set contains the most relevant information about a trading day such as transaction prices and quantities, dealer's inventory, and who initiated the trade.

Since, we have this information for each trading day for this dealer, we can examine the dealer's market making behavior and test if he takes advantage of the low transparency of customers' or interbanks' order flow and if he manages his inventory shocks. Also, using data on trade counterparty identity, we examine the impact of information coming from different types of trades (customer or interdealer trades) on the dealer's strategic behavior.

Our results support information and inventory effects for the dealer's pricing decision of the USD/TND exchange rate, but no information and inventory effects for the pricing decision of the EUR/TND. The information effect also depends on the trade counterparty identity. Finally, the TCB intervention appears significant and informatives only for the dealer's pricing decision for the USD/TND. Hence our results support some microstructure explanation for the market making behavior of a Tunisian FX dealer.

The remainder of the paper is organized as follows, Section 2 quickly surveys the main contributions of the literature on the pricing decision of FX market makers. Section 3 presents the main characteristics of the Tunisian foreign exchange market. Section 4 presents our model inspired from Madhavan and Smidt (1991). Section 5 describes the dataset that is used. Results are presented and discussed in section 6. Section 7 concludes.

0.2 Literature Review

Lyons (1997), who modelized the market making behavior for a FX trader, finds for two main microstructural models: the inventory control model and the asymmetric information model. The first model (e.g Garman, 1976; Amihud and Mendelson, 1980; Ho and Stoll, 1981, among other) focuses on how risk-averse dealers adjust prices to control their inventory of an asset. They adjust price or shade quotes, to offset order flow information. The dealer with a larger inventory of the currency than desired, will set a lower price to attract buyers. Thus, the spread arises as compensation to the market maker for not being able to hold the preferred portfolio. Information based models (e.g. Kyle, 1985; Glosten and Milgrom, 1985; Admati and Pfleiderer, 1988) consider adverse selection problems when some dealers have private information. When dealers receive trades, they revise their expectations and set spreads to protect themselves against informed traders. Both inventory control models and information-based models imply that buyer-initiated trades push up prices, while seller-initiated trades push prices down. Empirical studies try to disentangle the two effects and their impact on pricing decision and order placement strategy of dealer.

Lyons (1995) is the first who studies empirically the market making behavior of a FX trader. He uses dealer's intraday inventory and trade data on FX markets. He supports both asymmetric information and inventory control models. The main weakness of his findings is related to the dataset he uses. It spans only 5 trading day and it is not clear whether these days or the dealer are representative of the market. Moreover, customers' order are missing. Customers' trades are important in microstructure models because they represent the major source of asymmetric information. In this area, Yao (1997) studies the market making behavior of FX dealers in the interbank market, using a dataset based on complete trade records of a FX dealer at a major commercial bank over 25 trading days. His main results support the information effect of incoming trades. But he does not confirm the evidence of inventory control. Bjønnes and Rime (2005) find that customers' order are the most important source of private information and, consequently, spreads to customers are wider than spreads to other dealers. Hannover and Menkhoff (2003) have examined the differentiation of trading information between dealers, commercial and financial customers for USD/EUR exchange rate of a medium-sized bank in Germany. They find that these differences matter: order flows of financial customers are more informative even at the low frequency. Carpenter and Wang (2003) have examined the information content of trades' different participants via different trading channels. They conclude, following Rime (2000), that the information content is the greatest central bank's orders, followed by non-bank financial institutions' order. On the interbank market, dealers with greater private information prefer trade with his concurrent directly not by a **courtier** which has lower post-trade transparency.

0.3 Tunisian foreign exchange market

In this section, we present the main characteristics of the Tunisian foreign exchange market. The liberalization process of foreign exchange's regulations, started in 1987, led in December 1992 to the dinar current convertibility. Since then, resident corporates can freely transfer the amounts of their imports of goods and services. They were aligned, on this level, to fully-exporting corporates which have gained, since 1972, from foreign exchange total freedom for operations pertaining to their production activities. This process was accompanied, for capital transactions, with the freedom given :

- To resident corporates partly or fully-exporting to invest abroad in order to back up their exporting effort ;

- To banks and corporates to borrow in foreign currencies for their activities needs within the limits of TND10 and TND3 million per year respectively. Under the term of new regulations, lending institutions can borrow a limited amount of funds from non residents as long as the loan is for a period of more than 12 months, while other institutions are held to a 10 million dinar limit.

- To foreign investors to take portfolio participations accounting at least for 50% in listed or unlisted Tunisian corporates.

In addition a foreign exchange market was opened in March 1st, 1994. The exchange rate of the Tunisian dinar is now determined on the foreign exchange market between official intermediates of the Tunis area including offshore banks operating on behalf of their resident customers. The Central Bank of Tunisia (TCB) intervenes on this market and publishes the daily exchange rate of currencies and bank notes at the latest the following day.

The total turnover on foreign exchange market[1] was, in 2004, about 28.512 millions dinars (MDT) per day. The spot trades were predominate relative to forward and swaps transaction, with a market share of 94%.

Transactions on the spot foreign exchange market in 2004 amounted to 26,600 MTD. This was the result of the higher volume of transactions both

[1] The foreign exchange market encloses : spot, forward market and swaps.

for foreign currency/dinars (1,965 MTD) and from one foreign currency to another (3,674 MTD). The share of transactions from one foreign currency to another in overall foreign exchange spot transactions is by 62%.

These kinds of trading can made through the domestic or the foreign interbank FX market. But, on order to simplify our model, we assume that the first kind of trading exists only on domestic interbank FX market and that on the foreign interbank FX market, the Tunisian dealer trades, only hard currencies.

Trading in the foreign exchange market occurs in two separate sub markets; first, customers trading with a bank, and second, the interbank market where banks trade with each other. Although customers'order flow only account for about 40%[2] of the total transaction volume in the foreign exchange market, they are important because they generate the majority of trading profits for most foreign exchange dealers. Trading with customers is also regarded as an important source of private information. This information is private since only the dealer in the specific bank has knowledge of each trade.

The foreign exchange market is dominated by interbank trades with almost to 60% of total trades. The interdealer transactions are only direct trading through the Reuters D2000-1 and through the phone. Indirect trading through a broker do not exist on this market.

While major currencies are traded globally and constitute very liquid markets, smaller currencies like the Tunisian dinar (TND) are only traded through a national center and are less liquid. The euro is, the most actively traded currency, being involved in $54,5\%$ of all transactions on Tunisian foreign exchange market. The dollar follows, with almost $42,4\%$[3].

The tunisian central bank (TCB) controls frequently the TND and publishes a daily reference exchange rate transmitted to bank each day at 11pm. This strategy used by TCB to defend the domestic currency against the fluctuation of the others currencies and can help dealer to infer a private information known by the TCB.

Also, a regulations are imposed by the TCB in order to control the actions of dealers and in order to border their loss and wins. The TCB imposes that the variation of exchange rate of each dealer is limited to 3%. If one dealer exceeds this plafond, he must sell his position to TCB.

Over the period cover this paper (March 2002, November 2003), the

[2] This value was proxied by the author by means of sent to a questionnary all commercials tunsians banks.

[3] These statistics are from the annual report of TCB .

dinar depreciated against the EUR by 8.1% and by 1.4% against the USD. But, we remark that the appreciation of dollars by 10%, for the 16 first months followed by a depreciation of 8% (see fig 1).

The figure 1 exhibits a negative and asymmetric correlation between the two exchange rates. In fact, an appreciation of euro is accompanied by a depreciation of dollar.

Figure 1: *EUR/TND and USD/TND Interbank Exchange Rate 2000-2003*

0.4 The Model

This section presents the model which we test empirically in section 5. We use the model of Madhavan and Smidt (1991), which is used the same model as in Lyons (1997) and Rime (2000).

Consider a pure exchange economy with a risk free asset (domestic currency) and a risky asset, represented by foreign currency. There are N dealers (our dealer represent by i and his competitor note by j) and T periods (the whole trading days). The model's focus is on the pricing and order placement decisions of a dealer i, and each period is characterized by one incoming order for the dealer i's quote.

At time T (the end of the day), the true value, $\tilde{V}$, of the currency is revealed. This value is determined by the arrival of public information, denoted by r. It is composed of a series of increments (e.g. interest differentials) such that

$$\tilde{V}_T = \sum_{t=0}^{T} \tilde{r}_t. \tag{1a}$$

At the 0 (at the beginning of the trading day), the value is known and equal to r_0. After trading in period t (t=1, 2, ...,T), there arrives a new public information $r_t \sim IID(0, {\sigma_r}^2)$ and $\tilde{r}_t = V_t + \tilde{\omega}_t$ with $\omega_t \sim IID(0, {\sigma_r}^2)$.

Therefore, we can rewrite the equation as follow$(1a)$:

$$V_T = \sum_{t=0}^{T-1} r_t + \tilde{r}_T \tag{1b}$$

r_t, which represent the public information related to the trading day, is revealed at the end of the day. Hence this information is considered as private information at the beginning of the trading day, denoted μ_t. Hence, the equation $N°(1b)$ is described as :

$$V_t = V_{t-1} + \mu_t \tag{1c}$$

The private information, μ_{it} of dealer i is expected at two times. First, the dealer exchanges with his customer. The customer may have private information when he contacts the dealer i, while dealer i does not have access to private information hen he quotes prices. To take account of this asymmetry, dealer i quotes prices that can be contingent on order size. After the trade, dealer i can revise the quotes for the next trade based on new public information. the expected private information, in this case, is denoted by μ^1_{it}. This new information can be taken into on the next exchange with domestic and foreign dealers. Also, dealer j[4], with whom dealer i exchanges, may have private information that is not known by dealer i. This later will revise the quotes taking account of the dealer private information equal to μ^2_{it}.

In reality, prices will deviate from expected values because of microstructure elements. The Madhavan and Smidt model incorporates information and inventory effects through two postulated behavioral equations :

$$P_{it} = V_{t-1} + \mu_{it} - \varrho \left(I_t - I^*\right) + \gamma D_t \tag{2a}$$

[4] j can be domestic (l) or foreign (k) dealer.

$$Q_{jt} = \theta \left(\mu_{jt} - P_{it} \right) + X_{jt} \tag{2b}$$

The first equation (2a) is a typical inventory model. In this model, price (P_{it}) is linearly related to the dealer's current inventory (I_{it}), μ_{it} is the expectation of V_t conditional on information available to the dealer i at t, and I_i^* is the desired inventory position. The inventory response effect ($\varrho > 0$) is negative because the dealer may want to reduce his price to induce a sale if the inventory is above the preferred level. The term D_t is a direction-dummy that takes the value 1 if it is a sale (trade at the ask) and (-1) if it is a buy (trade at the bid), as seen by dealer i.

The second behavioral equation (2b) defines the quantity (Q_{jt}) that the dealer j wants to trade with the dealer i in period t, where μ_{jt} is the expectation by dealer of V_t, conditional on information available to dealer j at time t, and X_{jt} is an idiosyncratic shock that represents inventory-adjustment trading. The demand of the contacting dealer j, (2b), is optimal when dealers maximize exponential utility over end-of-period wealth. Thus, the quantity dealer j chooses to trade is linearly related to the deviation between dealer j's expectation and dealer i's price quote (P_{it}), plus a term representing inventory-adjustment trading. Since X_{jt} is only known to trader j, Q_{jt} only provides a noisy signal to dealer i of V_t. Note that Q_{jt} will be positive for sales to dealer j and negative for purchases.

Dealer i will set price such that it is ex post regret-free after observing the trade Q_{jt}. Regret-free, in the sense of Glosten and Milgrom (1985), means that conditional on observing the size and the direction of the order, dealer i does not want to change his quote. In reality, dealers give both by and sell prices for given quantity. If the contacting dealer sells, the ask price reflects the expectation conditional on a sell.

This model is tested for a tunisian dealer with an extension taking into account the microstructure of foreign tunisian market, discussed in section 3.

First, the pricing decision of the tunisian dealer is related to his pricing decision in the domestic interbank market (P_{it}) and in the foreign interbank market ($P_{it}^{'}$). Also, we have introduced the intervention of central bank, in equation (2a), in order to take into account the impact of the central bank interventions on the pricing decision of dealer in domestic interbank. This variable is measured by the exchange rate transmitted by TCB as reference (section 3) (SP). However, in the foreign interbank market, the domestic central bank can not intervene to control the tunisian dealer. Hence, we assume that dealer's pricing decisions on the foreign interbank market depend on the variability of EUR/USD exchange rate. This later is measured by this volatility (h). Hence the equation (2a) can be rewritten :

$$P_{it} = V_{t-1} + \mu_{it} - \varrho\left(I_t - I^*\right) + \rho SP_t + \gamma D_t \tag{3a}$$

$$P_{it}^{'} = V_{t-1}^{'} + \mu_{it}^{'} - \varrho\left(I_{it} - I^*\right) + \varphi h_{I,t} + \gamma D_t \tag{3b}$$

We have distinguished between domestic and foreign dealer. Therefore, the dealer i receives order both from domestic and foreign dealer. Hence, the equation (2b) can be divided in two equations as follow :

$$Q_{lt} = \theta\left(\mu_{lt} - P_{it}\right) + X_{lt} \tag{4a}$$

$$Q_{kt} = \theta(\mu_{kt} - P_{it}^{'}) + X_{kt} \tag{4b}$$

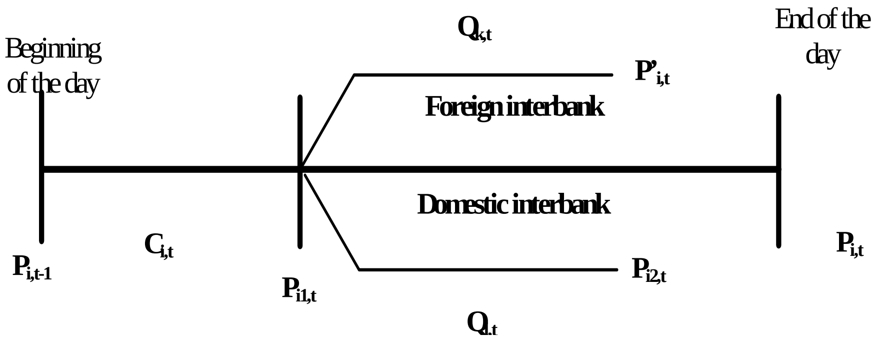
Where the first equation defines the quantity, Q_{lt}, exchanged between the domestic dealer i and a domestic dealer l, and the second defines the quantity, Q_{kt}, exchanged between the domestic dealer i and a foreign dealer k. The dealer j's (j=l,k) posterior (μ_{jt}) can be expressed as :

$$\mu_{jt} = \lambda\mu_t + (1-\lambda)\, C_{jt}$$

Where C$_j$ is dealer 's the customers' order.

When transparency is low, there may exist private information and this can be modelled through the informational environment that figure summarizes (2)the information structure seen from point of view of dealer i :

Figure 2: *The Structure of Information*



This figure denotes that the dealer behavior concerns his price and his order placement, taking into account of the different counterparties and his inventory control. In the following, we present, firstly, the pricing decision and secondly order placement strategy.

0.4.1 The pricing decision

At the period 0, the position of dealer i and his price are known for the period (-1) and are respectively $I_{i,t-1}$and $P_{i,t-1}$. This later is written in equation (3a) as:

$$P_{it-1} = V_{t-2} + \mu_{it-1} - \varrho\,(I_{t-1} - I^{*}) + \rho SP_{t-1} + \gamma D_{t-1} \tag{5}$$

Also at the beginning of each period t, dealer i receives a private signal C_{it} of V_t,

$$\tilde{C}_{it} = V_t + \tilde{\zeta}_i$$

where the noise term, $\tilde{\zeta}_i$, is independently normally distributed around zero with σ^2_ζ. Customers dealers are an important source of private information. To derive the price-schedule we need to insert for the expectations in (1a) and (1b). After observing the private signal C_{it}, dealer i's posterior (μ_{it}) can be expressed as :

$$\mu^1_{it} = (1 - \lambda)\,C_{it} \tag{6}$$

Where λ is equal to $\frac{\sigma^2_\zeta}{\sigma^2_\zeta + \sigma^2_\omega}$

And $\tilde{\zeta}_t$ and $\tilde{\omega}_t$ are independently.

At period 1, dealer i receives a private signal Q_{lt} and Q_{kt}, from domestic and foreign dealers. Dealer i conditions on various possible Q_{jt} and Q_{kt}'s when setting his prices. More specifically, dealer i forms the sufficient statistics Z_{lt} and Z_{kt} given by :

$$Z_{lt} = \frac{Q_{lt}/\theta + P_{it} - V_{t-1}}{1-\phi} = C_{lt} + \frac{1}{\theta\left(1-\phi\right)}X_{lt} \tag{7a}$$

$$Z_{kt} = \frac{Q_{kt}/\theta + P_{it}^{'} - V_{t-1}^{'}}{1-\phi} = C_{kt} + \frac{1}{\theta\left(1-\phi\right)}X_{kt} \tag{7b}$$

Z_{lt} and Z_{kt} are normally distributed with mean V_t and variance $\sigma_{Z_l}^2$ and $\sigma_{Z_k}^2$. Dealer i's posterior belief in interbank (μ_{it}^2) is a weighted average of Z_{lt} and Z_{kt} and can be expressed as :

$$\mu_{it}^2 = d_t \alpha Z_{lt} + d_t\left(1-\alpha\right) Z_{kt} \tag{8}$$

Where d_t takes the value 1 if dealer i does not exchange on the interbank market and 0 otherwise, and α is the probability of a trade on the tunisian interbank market.

Z_{lt} and Z_{kt} are statistically independent of μ_t. At the end, of day, the dealer i's posterior belief (μ_{it}) is a weighted average of μ_{it}^1 and μ_{it}^2 :

$$\mu_{it} = \kappa\mu_{it}^1 + \left(1-\kappa\right)\mu_{it}^2 \tag{9a}$$

Or

$$\mu_{it} = \kappa\mu_{it}^1 + \left(1-\kappa\right)\left(d_t\alpha Z_{lt} + d_t\left(1-\alpha\right)Z_{kt}\right) \tag{9b}$$

With $\kappa = \frac{\alpha\sigma_{Z_l}^2 + (1-\alpha)\sigma_{Z_k}^2}{\alpha\sigma_{Z_l}^2 + (1-\alpha)\sigma_{Z_k}^2 + \sigma_\omega^2}$

Using the two first equality in (7a) and (7b), we see that dealer i's posterior belief is expressed as a function of any Q_{lt} and Q_{kt} (for more detail see the appendix) :

$$\begin{aligned}\mu_{it} \quad = \quad & \kappa\left(1-\lambda\right)C_{it} + \frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}Q_{lt} + \frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}P_{it} - \frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}V_{t-1} \\ & + \frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\left(1-\alpha\right)Q_{kt} + \frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\left(1-\alpha\right)P_{it}^{'} \\ & - \frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\left(1-\alpha\right)V_{t-1}^{'} \end{aligned} \tag{10}$$

This equation denotes that μ_{it} is function of $V_{t-1}$and V'_{t-1}. These variables can be defined using equations N°(3a) and N°(3b) and inserting into (10) gives (for more detail see the appendix) :

$$\begin{aligned}\Delta P_{it} &= \beta_0 + \beta_1 C_{it} + \beta_2 Q_{lt} + \beta_3 Q_{kt} + \beta_4 \Delta P'_{it} + \beta_5 I_{it} + \beta_6 I_{i,t-1} \\ &\quad + \beta_7 D_{t-1} + \beta_8 D_t + \rho \Delta SP_t + \epsilon_t \end{aligned} \tag{11}$$

This baseline model corresponds to the model in Rime (2005), excluding his variable on market wide order flows. Since we are computing the price change between two successive incoming trades, the perfect collinearity between inventory and trade quantity breaks down. Also, our model is different from Rime's model in the fact that we distinguish between domestic and foreign interdealer. Therefore, the pricing decision of a dealer depends on his pricing decision on foreign interbank market (P'_{it}).

On The interbank market, The option for trading TND, available to dealers in the interbank market, are of to sorts :

- The dinar is directly exchanged against hard currency.

- The dinar is exchanged indirectly with at least two hard currencies. For instance, buying TND by selling EUR that is bought against USD.

0.4.2 Foreign interbank pricing decision (P'_{it})

The determination of pricing decision in the foreign interbank market (P'_{it}).is similar to the pricing decision in the domestic interbank (P_{it}).

The dealer i receives a private information from his customer order. The customer, we assume, has the possibility to trade dinar order against hard currency order and he can not exchange directly hard currency order against hard currency. Hence the dealer i receives a private information from, at least, two types customer order (C'_{it}).[5] Hence dealer i's posterior ($\mu^{1'}_{it}$) can be expressed as $\mu^{1'}_{it} = (1-\lambda) C'_{it}$.

In the foreign interbank, dealer i receives a private signal Q_{kt} and forms the sufficient statistics Z_{kt} given by (7a).

The dealer i's posterior belief (μ'_{it}) is expressed as a function of any C'_{it} and Q$_{kt}$:

$$\mu'_{it} = \kappa (1-\lambda) C'_{it} + d_t (1-\kappa) Z_{kt}$$

This equation inserted into (3b) yields (for more detail see the appendix $N°2$) :

[5] for example C'_{it} is the sum of euro customer and dollar customer order.

$$\Delta P_{it}^{'} = \beta_0^{'} + \beta_1^{'} C_{it}^{'} + \beta_2^{'} Q_{kt} + \beta_3^{'} I_{it} + \beta_4^{'} I_{i,t-1} + \beta_5^{'} D_t + \beta_6^{'} D_{t-1} + \varphi h_{aMI,t} \quad (12)$$

Finally, our baseline model is described as follow :

$$\begin{aligned}
\Delta P_{it} &= \beta_0 + \beta_1 C_{it} + \beta_2 Q_{lt} + \beta_3 Q_{kt} + \beta_4 \Delta P_{it}^{'} + \beta_5 I_{it} + \beta_6 I_{i,t-1} \\
&\quad + \beta_7 D_t + \beta_8 D_{t-1} + \beta_9 JNO + \rho \Delta SP_t + \epsilon_{it} \\
\Delta P_{it}^{'} &= \beta_0^{'} + \beta_1^{'} C_{it}^{'} + \beta_2^{'} Q_{kt} + \beta_3^{'} I_{it} + \beta_4^{'} I_{i,t-1} + \beta_5^{'} D_t + \beta_6^{'} D_{t-1} \\
&\quad + \beta_7^{\prime} JNAD + \varphi h_{aMI,t} \qquad (13)
\end{aligned}$$

The dummies variables JNO and $JNAD$ describe respectively the absence of dealer's exchange in domestic and foreign interbank.

β_1, $\beta_1^{'}$, β_2, $\beta_2^{'}$and β_3 measure the information effect, while $\beta_4^{'}$ and β_6 measure the inventory effect, and $\beta_5^{'}$ and β_7 measure the transaction cost. The model predicts that $\left\{\beta_1, \beta_1^{'}, \beta_2, \beta_2^{'}, \beta_3, \beta_5^{'}, \beta_7\right\}>0$ and $\left\{\beta_5, \beta_8, \beta_6^{'}\beta_3^{'}\right\}<0$, as Rime's model. Also, in our model, ρ, $\beta_4$and φ measure, respectively, the intervention TCB, pricing decision in foreign interbank and the variability of foreign exchange market. This model predicts that $\{\rho, \beta_4, \varphi\} > 0$.

0.5 Data

The data set, employed in this study, consists of daily transactions of the two major currencies in terms of Tunisian Dinars, namely the Dollar(USD/TND) and Euro (EUR/TND). The data is appropriate to a commercial and private Tunisian middle-sized bank over the sample period 01 March 2000 to 28 November 2003. The market share is about 5%. His market is dominated by interbank transaction, 70%.

Our model considers incoming and outgoing transactions. All variables are measured in USD for the USD/TND dealers and in EUR for the EUR/TND.

0.5.1 Data description

Descriptive statistics for relevant variables used in estimation are reported in table $N°1$. To analyze the statistical properties of the exchange rate of the Tunisian Dinar we compute the first difference of the log of the exchange rate defined as $r_t = \ln(S_t/S_{t-1})$. The characteristics of relative returns exhibit a quite small and negative for the two exchange rates.

On other hand the data exhibit an excess kurtosis for the two exchange rates suggesting the presence of a high peak and a fat tails compared to the normal distribution.

Also, the data show small levels of skewness which are negative. These values suggest that the data are approximately symmetric. The negative value of skewness is in conformity with the sustained trend toward depreciation exhibited of Tunisian Dinar.

These summary statistics show that data are approximately symmetric with high peaks and extreme values in the tails.

Figure 3: *The Dealer Exchange Rate of EUR/TND and USD/TND*

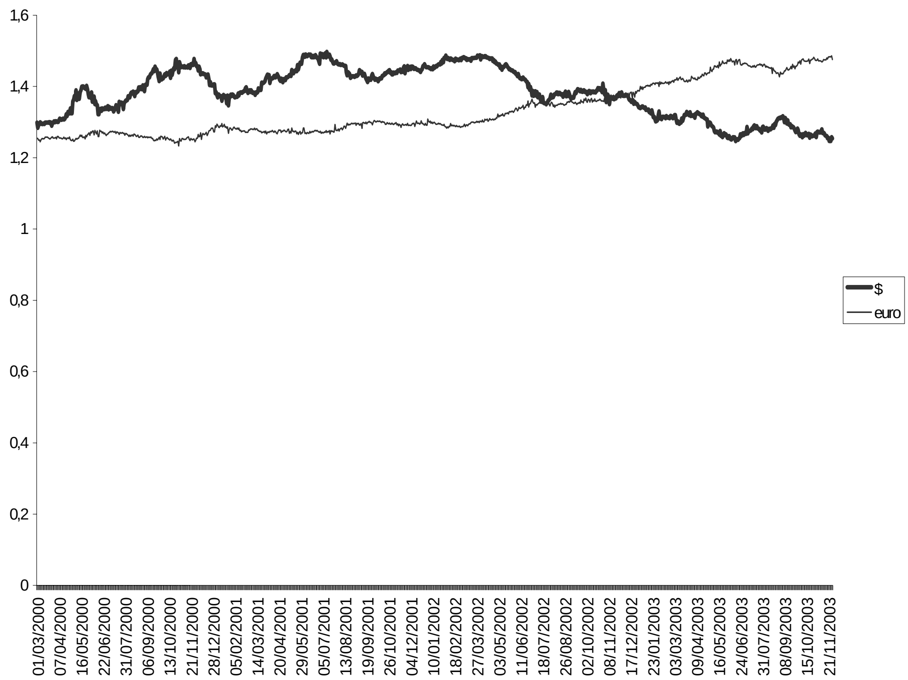


Table $N°1$: Descriptive statistics

	ΔP_{it}	$\Delta P_{it}^{'}$	C_{it}	Q_{lt}
		USD		
$Mean$	-0.003	-0.068	314.521	1546.959
$Maximum$	2.500	4.21	7328.642	4412.1
$Minimum$	-2.456	-3.917	-7776.83	-5396
$Std.Dev.$	0.527	0.5958	1255.503	1623.52
$Skewness$	-0.017	0.2017	0.624	0.806
$Kurtosis$	5.783	3.60	2.0597	2.770
		EUR		
$Mean$	-0.016	0.021	240.153	189.226
$Maximum$	1.469	2.754	5197.564	7250
$Minimum$	-1.645	-2.320	-4260.03	-12045.2
$Std.Dev.$	0.381	0.679	675.865	1102.022
$Skewness$	-0.083	-0.002	0.196	-0.461
$Kurtosis$	5.181	3.604	2.796	2.080

	Q_{kt}	I_{it}	P_t	T_{it}
		USD		
$Mean$	-0.50231	15.345	0.757	928.175
$Maximum$	48.480	5096.420	0.7946	2647.9
$Minimum$	-140.73	-5281.058	0.7285	-3237.6
$Std.Dev.$	12.61	1250.902	0.020	9743.113
$Skewness$	12.611	-0.2930	-0.082	2.80646
$Kurtosis$	48.53	6.4942	1.705	0.7700
		EUR		
$Mean$	-0.50231	454.749	0.744	113.536
$Maximum$	48.48	5064.463	0.806	4350
$Minimum$	-140.73	-4617.103	0.611	-7227.169
$Std.Dev.$	-140.732	1160.779	0.046	661.213
$Skewness$	12.611	0.293	-0.749	-0.461
$Kurtosis$	48.53	5.6150	2.429	3.080

The analysis of descriptive order flow counterparty, summarized in table $N°2$, show that euro customer orders are the most order of the EUR/TND exchange rate. These exceed the half (64%) of aggregated orders flows. However, for the USD/TND exchange rate, its represent less than the fifth 17%.

On other hand, the interbanks' orders are important for the USD (83%), which represent the majority of aggregated order. While, 95% of this percentage represent the domestic orders But the euro interbank do not exceed

36% of aggregated orders and 78% of them are domestic interbanks' order.

These summary show that the dollar is used to satisfy the euro and dollar customer order. The dollar is more liquid in the whole of the word. Also, at the period, covered this study, his evolution is not predictable that why the dealer trades in most with dollar in order to exploit it when the euro is stable. But over, the dealer is a buyer in the interbank market since his order net placement is positive for the two exchange rates.

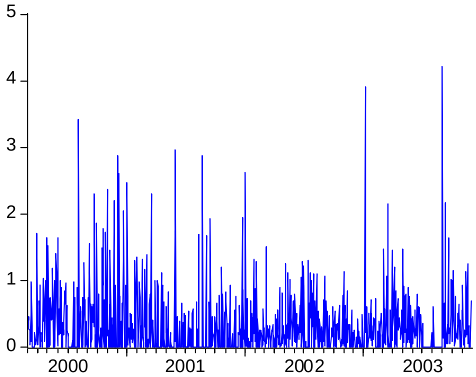
Table $N°2$: Transaction types

	USD/TND	EUR/TND
Interbank	83	36
Domestic	96, 75	78
foreign	3, 25	22
Customer	17	64

0.5.2 EUR/USD exchange rate volatility

The pricing decisions on the foreign exchange market depend on the volatility of international market. This later is computed by the volatility of EUR/USD exchange rate (figure N°4). In fact, this exchange rate represent the two major currencies trading in the word. This volatility is measured by the absolute return.

Figure 4: *EUR/USD Exchange Rate Volatility*



As known, the presence of autoregressive conditional heteroscedasticity in daily foreign exchange returns is well known. This phenomena is described by GARCH (1,1) (Baillie and Bollerslev 1989) Therefore, we use GARCH (1,1) forecasted volatilities from daily log returns USD/EUR to measure the h_{aMI}. Table $N°3$ reports this GARCH estimation and likelihood-ratio test rejecting conditional homoscedasticity and ARCH (1) against GARCH(1,1).

$$\begin{aligned} R_t &= \mu + \epsilon_t \\ h_t &= \alpha_0 + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \end{aligned} \tag{14}$$

Table $N°3$: GARCH (1,1) estimation model for USD/EUR volatility

USD/EUR	μ	α_0	α_1	β
	0.484	0.003	0.016	0.966
	(31.534)	(1.923)	(3.124)	(75.731)
Likel-ratio tests GARCH(1,1)				
against ARCH(0) and ARCH(1)		$\chi^2(2) = 2.469$		
		$\chi^2(1) = 0.0038$		

0.5.3 The Order Stationary test

In order to avoid the problem of colinearity between inventory, and order this later can be measured by his unexpected component.

The two series seem to be left asymmetric and leptokurtic. The stationary test seems reject the null hypothesis, as reported in table $N°4$.

Table $N°4$: Test of stationary

USD/TND	-22.071
EUR/TND	-7.805

significant at level 1%, 5%, 10%

0.5.4 Inventory positions

A dealer starts the day with his overnight position, and enters his trades during the day. We can therefore track the dealers' inventory positions. The record gives the dealers' information on their inventories and accumulated profits during the day.

Table N°1 presents inventory positions measured on USD for the USD/TND and on EUR for the EUR/TND exchange rates. There are pronounced differences in the development of dealer inventories during the period. Dealer's maximum long dollar position was USD 50 million, while the maximum short dollar position was USD 52 million. For the euro, the dealer's maximum long euro position was EUR 50 million, while the maximum short euro position was EUR 40 million.

The dealer ends the day with a position different to zero. This finding is in contrast with Lyons (1995) and Yao (1997). As the Tunisian FX market is small and less liquid than the major market, the dealer, which is risk averse, will manage his inventory to protect against the loss that exceed a 10% of his position.

0.6 The Results

We start with presenting the method of regression. Next, we discuss the results in two cases :

1- The absence of TCB intervention

2- the Presence of TCB intervention

0.6.1 Method

The model, presented by the equation system $N°13$), is estimated by the Generalized Method of Moments (GMM) of Hansen (1982), with the Newey and West (1987) correction of the covariance matrix for heteroscedastisty and autocorrelation of unknown form.

Hansen's GMM estimation involves the use of over-identifying moment restrictions implying from the model, in order to estimate coefficients and heteroskedastic and autocorrelation consistent standard errors. Also, GMM takes account the interaction between parameters that are endogenous, such as for the exchange rate.

In all of the regressions, the set of instruments equals the set of regressors. In this case, as noted by Bessembinder (1994), we could not test for the overidentifying restrictions.

0.6.2 Empirical Results

In this section, we present the estimations' results of the dealer's pricing decisions

$$
\begin{aligned}
\Delta P_{it} &= \beta_0 + \beta_1 C_{it} + \beta_2 Q_{lt} + \beta_3 Q_{lt} + \beta_4 \Delta P_{it}^{'} + \beta_5 I_{it} + \beta_6 I_{i,t-1} \\
&\quad + \beta_7 D_t + \beta_8 D_{t-1} + \beta_9 JNO + \rho \Delta SP_t + \epsilon_{it} \\
\Delta P_{it}^{'} &= \beta_0^{'} + \beta_1^{'} C_{it}^{'} + \beta_2^{'} Q_{kt} + \beta_3^{'} I_{it} + \beta_4^{'} I_{i,t-1} + \beta_5^{'} D_t + \beta_6^{'} D_{t-1} \\
&\quad + \beta_7^{\prime} JNAD + \varphi h_{aMI,t} \qquad (15)
\end{aligned}
$$

The results investigating, whether the dealer utilizes their private information and inventory in pricing, are somewhat ambiguous. Several of the coefficients are the correct sign, as predicted, and significant. However, we also have cases with opposite sign and insignificant coefficients.

Tables $N°5$ and $N°6$ present our estimation of the equation system $N°13$.

The coefficients $\beta_1^{'}$and $\beta_2^{'}$ for USD/EUR are correctly signed and significant for the tow exchange rate. Also, the coefficients β_1 and β_2 are positives and significant, only for USD/TND (table $N°6a$). But orders have not the same effect. The effect of customers' order on the change of dinar against USD, is less than the domestics interbanks' orders. The effect of domestics' order is three times larger than the customers' order. However, the foreign interbanks' orders have no effect that his coefficient β_3 is insignificant.

When he trades on the domestic interbank market, the interbanks' order is more informative than customer. Hence, interbank is probably the most informative trading channel. The dealer also had agreements to trade with several dealers, making it important to protect against private information. This may explain the information effect. Also, the reason why this difference between customers and domestic interbank dealers, is that the customers have a liquidity motivation of trade. While, on the interbank market, the dealers have liquidity, arbitrage, speculation and information motivation.

The inventory effects, through quote shading, have a positive effect ($\beta_4^{'}$ and β_6) for the EUR/USD, USD/EUR and USD/TND. This is in contrast with the results of Bjønnes and Rime (2005), who find the absence of inventory control. Therefore, the dealer is risk averse and wants to transfer the risk generated by the trade with his customer to his competitor.

The coefficients $\beta_5^{'}$ and β_7 of transactions costs are significant and correctly signed for the EUR/USD and the USD/TND exchange rates. Hence, This makes the presence of transactions costs. For the absence of transactions on the interbank market (the dummies variables), we show that the coefficients are negatives and significant for all exchange rates. Thus, as dealer do not trade on the interbank market, his price will decrease because the information effect of no transaction. Finally, the variability of international market and the pricing decision of our dealer on the foreign interbank, have a positive and a significant effect on the foreign pricing decision. Hence, as the international market becomes more volatile, the dealer will increase his price in order to protect against the arrival of several information. This result is with the information microstructure theory (Admati and Pfleiderer, etc.), and these information will be affected the domestic pricing decision via the foreign price.

These results are analyzed with assumption of the absence of TCB intervention. While, we include in our model this variables, the coefficients keep the same sign, as presented in table $N°6b$. Thus, we let the same interpretation, with the fact that TCB will induce our dealer to increase his price of USD/TND, because the coefficient is positive and significant. This can be explained that the TCB is the most informative agent on the foreign exchange market.

Also, As announced at the beginning of this section that the coefficients of the EUR/TND are not significant. The reason can be explained that EUR/TND, in this period $(2000-2003)$, was stable and hence his variation is predictable. Unlike the USD was characterized by a higher instability and a higher unpredictably.

Table $N°5$: Foreign interbank-pricing USD/EUR and EUR/USD

$$\Delta P_{it}^{'} = \beta_0^{'} + \beta_1^{'} C_{it}^{'} + \beta_2^{'} Q_{kt} + \beta_3^{'} I_{it} + \beta_4^{'} I_{i,t-1} + \beta_5^{'} D_t + \beta_6^{'} D_{t-1} + \beta_7^{\prime} + \varphi h_{aMI,t}$$

	USD	EUR
$\beta_0^{'}$	0.329	0.296
	(2.293)	(2.288)
$C_{it}^{'}$	0.232	0.261
(+)	(2.506)	(3.1)
Q_{kt}	0.037	0.0458
(+)	(1.627)	(2.928)
I_{it}	-0.059	-0.0197
(-)	(-1.564)	(-1.626)
$I_{i,t-1}$	0.062	0.0189
(+)	(1.669)	(1.660)
D_t	0.021	-0.0131
(+)	(1.603)	(-0.889)
D_{t-1}	-0.004	0.0327
(-)	(-1.013)	(1.763)
$JNAD$	-0.021	-0.489
(-)	(-19.40)	(-17.14)
$h_{aMI,t}$	1.293	1.278
(+)	(1.854)	(2.072)
R^2	0.553	0.539
$N.O$	627	341

Table $N°6$: : Domestic interbank-pricing

$$\begin{aligned}\Delta P_{it} &= \beta_0 + \beta_1 C_{it} + \beta_2 Q_{lt} + \beta_3 Q_{kt} + \beta_4 \Delta P'_{it} + \beta_5 I_{it} + \beta_6 I_{i,t-1} \\ &\quad + \beta_7 D_t + \beta_8 D_{t-1} + \beta_9 JNO + \rho \Delta SP_t + \epsilon_{it}\end{aligned}$$

	USD/TND		EUR/TND	
	a^*	b^{**}	a^*	b^{**}
β_0	0.308	0.044	0.226	0.16
	(11.457)	(1.69)	(11.595)	(3.241)
C_{it}	0.070	0.067	0.079	0.135
(+)	(2.423)	(1.929)	(0.6468)	(0.819)
Q_{lt}	0.200	0.13	-0.485	0.045
(+)	(1.773)	(1.884)	(-0.377)	(0.059)
Q_{kt}	0.0497	0.028	0.0427	0.059
(+)	(0.928)	(0.920)	(0.7458)	(0.824)
$\Delta P'_{it}$	0.0706	0.029	0.0488	0.085
(+)	(2.556)	(1.811)	(2.415)	(2.225)
I_{it}	-0.199	-0.078	-0.102	-0.032
(-)	(-7.799)	(-1.985)	(-0.187)	(-0.678)
$I_{i,t-1}$	0.199	0.073	0.106	0.031
(+)	(7.794)	(1.972)	(0.195)	(0.664)
D_t	0.025	0.003	0.008	0.006
(+)	(2.255)	(1.8)	(0.812)	(0.063)
D_{t-1}	0.007	0.016	0.002	0.009
(-)	(0.691)	(1.039)	(0.381)	(1.047)
JNO	-0.086	-0.149	-0.050	-0.038
(-)	(-3.590)	(-3.601)	(-1.763)	(-1.983)
ΔSP		0.017	$--$	-0.023
(+)		(2.649)	$--$	(-1.526)
R^2	0.596	0.49	0.39	0.37
$N.O$	604		476	

a^*: *without TCB intervention*
b^{**}: *with TCB intervention*

0.7 Conclusion

This paper studies the behavior of one tunisian interbank foreign exchange dealer using a detailed data set from the period 2 March 2000 to 28 November 2003, with transaction prices, trading quantities, dealer inventories, and which trading system were used for the transactions. In particular, we study whether dealer sets prices to protect against private information, and to control inventory to adjust their risk exposure and how he fixes his order placement

In a widely cited paper, Rime (2005), using data of one week from 1998 for four dealers, found no support for such information or inventory effects. But Lyons (1995) found support for both information and inventory effects in the pricing of a market for one week from 1992. Using an extension of Lyons and Rime' model, we find support information and inventory effect only for USD/TND exchange rate, but not for the EUR/TND exchange rate. We believe that this is due to the characteristics of exchange rates. The USD/TND exchange rate, at period covering the study, was not stable as EUR/TND.

In microstructure theory, order flow is a private information, in particular the customer order. In this paper, we find three types of order : customer, domestic interbank and foreign interbanks' orders. Among all different types of order, dealer's domestic interbank and customer are informative for USD/TND. But the first one is the most important and informative order flow. But for EUR/USD (USD/EUR), the foreign interbank is the informative order than the customer order. Also, we find an inventory effect, only for the USD/TND exchange rate. Shading quotes signals a dealer's position.

Finally, our results indicate that the inclusion of TCB intervention seems be significant only on the dealer's pricing decision for USD/TND. Hence the Intervention TCB is informative for the exchange rate which is not stable.

Our model focuses, first, on the pricing decision of one market maker. We think it is important to also examine for others tunisian dealer. Also, we think is important to explore the market making behavior on the interbank market and includes other characteristics of the interbank trading. First, there is a need to better understand the use of outgoing trades (the aggressor's decision). Second, it is important to understand the dealer's choice between different trading channels. New theories that address risk management and information updating in a trading environment with both domestic and foreign trading are thus in great demand.

0.8 Appendix :Pricing decision

1−with customer, the dealer i's expectation, after observing the order customer is μ_{it}^{1}:

$$\mu_{it}^{1} = (1-\lambda)\, C_{it} \tag{16a}$$

With $\lambda = \frac{\sigma_{\varsigma}^{2}}{\sigma_{\varsigma}^{2}+\sigma_{r}^{2}}$

$$\mu_{jt} = (1-\lambda)\, C_{jt} \tag{17a}$$

2− In domestic interbank, the dealer i forms the sufficient statistic Z_{lt}

$$Z_{lt} = \frac{Q_{lt}/\theta + P_{it} - V_{t-1}}{1-\phi} = C_{lt} + \frac{1}{\theta\,(1-\phi)} X_{lt} \tag{18a}$$

With $Q_{lt} = \theta\,(V_{t-1} + \mu_{lt} - P_{it}) + X_{lt}$
$\mu_{lt} = (1-\lambda)\, C_{lt}$

3− In foreign interbank, the dealer i forms the sufficient statistic Z_{kt}

$$Z_{kt} = \frac{Q_{kt}/\theta + P_{it}^{'} - V_{t-1}^{'}}{1-\phi} = C_{kt} + \frac{1}{\theta\,(1-\phi)} X_{kt} \tag{18b}$$

$$Q_{kt} = \theta\left(V_{t-1}^{'} + \mu_{lt} - P_{it}^{'}\right) + X_{kt} \tag{18c}$$

In interbank (domestic and foreign), the dealer i's expectation, after observing the order interbank is $\overset{2}{\mu}_{it}$. This statistic is a weighted average of Z_{lt} and Z_{kt}, the dealer i's posterior(μ_{it}^{2})

$$\overset{2}{\mu}_{it} = d_t \alpha Z_{lt} + d_t\,(1-\alpha)\, Z_{kt} \tag{19}$$

Is the probability of exchange in domestic interbank

Hence, the dealer i's expectation (μ_{it}) about the true value is a weighted average of (μ_{it}^{2}) and $\left(\mu_{it}^{1}\right)$

$$\mu_{it} = \kappa \mu_{it}^{1} + (1-\kappa)\, \overset{2}{\mu}_{it} \tag{20a}$$

$$\mu_{it} = \kappa \mu_{it}^{1} + (1-\kappa)\,(d_t \alpha Z_{lt} + d_t\,(1-\alpha)\, Z_{kt}) \tag{20b}$$

We replace (Z_{jt} and Z_{kt}) from equations (18aand18b), we obtain :

$$
\begin{aligned}
\mu_{it} &= \kappa(1-\lambda)C_{it} + d_t(1-\kappa)\alpha\left[\frac{Q_{lt}/\theta + P_{it} - V_{t-1}}{1-\phi}\right] \\
&\quad + d_t(1-\kappa)(1-\alpha)\left[\frac{Q_{kt}/\theta + P'_{it} - V'_{t-1}}{-\phi}\right] \qquad (21a)
\end{aligned}
$$

Or μ_{it} is

$$
\begin{aligned}
\mu_{it} &= \kappa(1-\lambda)C_{it} + \frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}Q_{lt} \\
&\quad + \frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}P_{it} - \frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}V_{t-1} \\
&\quad + \frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}(1-\alpha)Q_{kt} + \frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}(1-\alpha)P'_{it} \\
&\quad - \frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}(1-\alpha)V'_{t-1} \qquad (21b)
\end{aligned}
$$

Then we have :

$$
P_{it} = V_{t-1} + \mu_{it} - \zeta(I_t - I^*) + \rho SP_t + \gamma D_t \qquad (22)
$$

Inserting equation (22), in (21b), we can write the price as P_{it}:

$$
\begin{aligned}
P_{it} &= V_{t-1} + \kappa(1-\lambda)C_{it} + \left[\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right]Q_{lt} + \left[\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right]P_{it} \\
&\quad - \left[\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right]V_{t-1} + \left[\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right](1-\alpha)Q_{kt} \\
&\quad + \left[\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right](1-\alpha)P'_{it} - \left[\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right](1-\alpha)V'_{t-1} \\
&\quad - \zeta(I_{it} - I^*) + \gamma D_t \qquad (23a)
\end{aligned}
$$

Or

$$
\begin{aligned}
P_{it} \;=\; & V_{t-1} + \kappa\left(1-\lambda\right)C_{it} + \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]Q_{lt} + \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]P_{it} \\
& - \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]V_{t-1} + \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)Q_{kt} \\
& + \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)P_{it}^{'} - \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)V_{t-1}^{'} \\
& -\zeta\left(I_{it}-I^{*}\right) + \rho SP_t + \gamma D_t \qquad \text{(24a)}
\end{aligned}
$$

Or

$$
\begin{aligned}
P_{it} \;=\; & \left[1-\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]V_{t-1} + \kappa\left(1-\lambda\right)C_{it} + \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]Q_{lt} \\
& + \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]P_{it} - \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]V_{t-1} \\
& + \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)Q_{kt} + \left[\frac{d_t\left(1-\kappa\right)\alpha}{\left(1-\phi\right)}\right]\left(1-\alpha\right)P_{it}^{'} \\
& - \left[\frac{d_t\left(1-\kappa\right)\alpha}{\left(1-\phi\right)}\right]\left(1-\alpha\right)V_{t-1}^{'} - \zeta\left(I_{it}-I^{*}\right) \\
& + \left[\frac{d_t\left(1-\kappa\right)\alpha}{\left(1-\phi\right)}\right]\rho SP_t + \gamma D_t \qquad \text{(24b)}
\end{aligned}
$$

The true value in domestic and foreign market at preceding trade are

$$
V_{t-1} = P_{it-1} + \zeta\left(I_{it-1}-I^{*}\right) - \rho SP_{t-1} - \gamma D_{t-1} \qquad \text{(25a)}
$$

$$
V_{t-1}^{'} = P_{it-1}^{'} + \zeta\left(I_{it-1}-I^{*}\right) - \varphi h_{I,t-1} - \gamma D_{t-1} \qquad \text{(25b)}
$$

These equations are replaced in equation $N^{\circ}(24b)$

$$
\begin{aligned}
\left[1-\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]P_{it} \quad = \quad & \left[1-\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left[P_{it-1}+\zeta\left(I_{it-1}-I^*\right)\right] \\
& -\left[1-\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left[\rho SP_{t-1}-\gamma D_{t-1}\right] \\
& +\kappa\left(1-\lambda\right)C_{it}+\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]Q_{jt} \\
& +\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)Q_{jt}^{'} \\
& +\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)P_{it}^{'} \\
& -\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)P_{it-1}^{'} \\
& -\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\varphi h_{I,t-1} \\
& -\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)\left[\zeta\left(I_{it-1}-I^*\right)-\gamma D_{t-1}\right] \\
& -\zeta\left(I_{it}-I^*\right)+\rho SP_t+\gamma D_t \qquad\qquad \text{(25c)}
\end{aligned}
$$

$$
\begin{aligned}
\left[1-\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\Delta P_{it} \quad = \quad & \left[1-\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left[\zeta\left(I_{it-1}-I^*\right)\right] \\
& -\left[1-\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left[\rho SP_{t-1}-\gamma D_{t-1}\right] \\
& +\kappa\left(1-\lambda\right)C_{it}+\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]Q_{lt} \\
& +\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)Q_{kt} \\
& +\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)\left(P_{it}^{'}-P_{it-1}^{'}\right) \\
& -\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\varphi h_{I,t-1}+\rho SP_t+\gamma D_t \\
& -\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)\zeta\left(I_{it-1}-I^*\right) \\
& +\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)\gamma D_{t-1} \\
& -\left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\zeta\left(I_{it}-I^*\right) \qquad \text{(25d)}
\end{aligned}
$$

Finally, the variation of price of $TND/$ hard currency is written as follow:

$$
\begin{aligned}
\Delta P_{it} &= \left[\frac{\kappa\left(1-\lambda\right)}{1-\left(\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right)}\right] C_{it} + \left[\frac{\left(\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right)}{1-\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}}\right] Q_{lt} \\
&+ \left[\frac{\left(\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right)(1-\alpha)}{1-\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}}\right] Q_{kt} \\
&+ \left[\frac{\frac{d_t(1-\kappa)\alpha}{(1-\phi)}(1-\alpha)}{1-\left(\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right)}\right] \left(P_{it}^{'} - P_{it-1}^{'}\right) - \varphi h_{I,t-1} \\
&+ \left[\frac{\frac{d_t(1-\kappa)\alpha}{(1-\phi)}(1-\alpha)}{1-\left(\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right)}\right] \left[\zeta\left(I_{it-1} - I^*\right) - \gamma D_{t-1}\right] \\
&- \left[\frac{1}{1-\left(\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right)}\right] \left[\zeta\left(I_{it} - I^*\right) - \gamma D_t\right] \\
&+ \left[\frac{\rho}{1-\left(\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right)}\right] SP_t - \rho SP_{t-1} \qquad (25e)
\end{aligned}
$$

Then we suppose the past volatility have no effect in variation of price. hence $(\varphi h_{I,t-1})$ is eliminated. Also, we suppose that $\phi<\kappa$ when $(\frac{d_t(1-\kappa)\alpha}{1-\phi})$is close to zero, our equation becomes:

$$
\begin{aligned}
\Delta P_{it} &= \kappa\left(1-\lambda\right) C_{it} + \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right] Q_{lt} + \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right) Q_{kt} \\
&+ \left[\frac{d_t\left(1-\kappa\right)\alpha}{\left(1-\phi\right)}\right]\left(1-\alpha\right)\left(P_{it}^{'} - P_{it-1}^{'}\right) \\
&+ \left[\frac{d_t\left(1-\kappa\right)\alpha}{\theta\left(1-\phi\right)}\right]\left(1-\alpha\right)\left[\zeta\left(I_{it-1} - I^*\right) - \gamma D_{t-1}\right] \\
&- \left[\zeta\left(I_{it} - I^*\right) - \gamma D_t\right] + \rho SP_t - \rho SP_{t-1} \qquad (25f)
\end{aligned}
$$

Or

$$
\begin{aligned}
\Delta P_{it} &= \beta_0 + \beta_1 C_{it} + \beta_2 Q_{lt} + \beta_3 Q_{kt} + \beta_4 \Delta P_{it}^{'} \\
&+ \beta_5 I_{it} + \beta_6 I_{i,t-1} + \beta_7 D_{t-1} \\
&+ \beta_8 D_t + \beta_9 JNO + \rho \Delta SP_t + \epsilon_t \qquad (26)
\end{aligned}
$$

With

$$
\begin{aligned}
\beta_1 &= \kappa(1-\lambda) \\
\beta_2 &= \left[\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right] \\
\beta_3 &= \left[\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right](1-\alpha) \\
\beta_4 &= \left[\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right](1-\alpha) \\
\beta_5 &= -\zeta \\
\beta_6 &= \left[\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right](1-\alpha)\zeta \\
\beta_7 &= -\left[\frac{d_t(1-\kappa)\alpha}{\theta(1-\phi)}\right](1-\alpha)\gamma \\
\beta_8 &= \gamma
\end{aligned}
$$

The determination of pricing decision in foreign interbank (P'_{it})
This price is written as :

$$P'_{it} = V'_{t-1} + \mu'_{it} - \zeta(I_{it} - I^*) + h_I + \gamma D_t \tag{27}$$

The dealer i's expectation $\left(\mu'_{it}\right)$ after trading in foreign interbank about the true value is a weighted average of ($\mu^{1\prime}_{it}$) and (Z_{kt}). $\mu^{1\prime}_{it}$ is the dealer i's expectation, after observing the order customer of EUR/TND and USD/TND.

$$\mu'_{it} = \kappa\mu^{1\prime}_{it} + (1-\kappa)Z_{kt} \tag{28a}$$

$\mu^{1\prime}_{it}$ is described as :

$$\mu^{1\prime}_{it} = (1-\lambda)C'_{it} \tag{28b}$$

C'_{it} order flow of EUR/TND and USD/TND.
Hence μ'_{it} is

$$\mu'_{it} = \kappa(1-\lambda)C_{it} + d_t(1-\kappa)Z_{kt} \tag{29}$$

Inserting equations N°28b and 18b in $N°(28a)$.We write μ'_{it} as:

$$\mu'_{it} = \kappa(1-\lambda)C_{it} + \frac{d_t(1-\kappa)}{\theta(1-\phi)}Q_{kt} + \frac{d_t(1-\kappa)}{(1-\phi)}P'_{it} - \frac{d_t(1-\kappa)}{(1-\phi)}V'_{t-1} \tag{30a}$$

Or

$$\mu_{it}^{'} = \kappa \left(1-\lambda\right) C_{it} + \left(1-\kappa\right) \left[\frac{Q_{kt}/\theta + P_{it}^{'} - V_{t-1}^{'}}{1-\phi}\right] \tag{30b}$$

$$\mu_{it}^{'} = \kappa \left(1-\lambda\right) C_{it} + \frac{d_t \left(1-\kappa\right)}{\theta \left(1-\phi\right)} Q_{kt} + \frac{d_t \left(1-\kappa\right)}{\left(1-\phi\right)} P_{it}^{'} - \frac{d_t \left(1-\kappa\right)}{\left(1-\phi\right)} V_{t-1}^{'} \tag{30c}$$

Inserting equation $N^{\circ}(30c)$ in $N^{\circ}(27)$, we obtain :

$$\begin{aligned} P_{it}^{'} &= P_{it-1}^{'} + \zeta \left(I_{it-1} - I^{*}\right) - \Phi_{t-1} - \gamma D_{t-1} + \epsilon_{it} + \left(1-\lambda\right) C_{it} \\ &\quad + \frac{d_t \left(1-\kappa\right)}{\theta \left(1-\phi\right)} Q_{kt} + \frac{d_t \left(1-\kappa\right)}{\left(1-\phi\right)} P_{it}^{'} - \frac{d_t \left(1-\kappa\right)}{\left(1-\phi\right)} V_{t-1}^{'} \\ &\quad - \zeta \left(I_{it} - I^{*}\right) + \varphi \delta_{MI,t}^{2} + \gamma D_t \end{aligned} \tag{31a}$$

$$\begin{aligned} P_{it}^{'} &= P_{it-1}^{'} + \zeta \left(I_{it-1} - I^{*}\right) - \Phi_{t-1} - \gamma D_{t-1} + \left(1-\lambda\right) C_{it} \\ &\quad + \frac{d_t \left(1-\kappa\right)}{\theta \left(1-\phi\right)} Q_{kt} + \frac{d_t \left(1-\kappa\right)}{\left(1-\phi\right)} P_{it}^{'} - \left(\frac{d_t \left(1-\kappa\right)}{\left(1-\phi\right)}\right) P_{it-1}^{'} \\ &\quad - \left(\frac{d_t \left(1-\kappa\right)}{\left(1-\phi\right)}\right) \left[\zeta \left(I_{it-1} - I^{*}\right) - \varphi \delta_{MI,t-1}^{2} - \gamma D_{t-1}\right] \\ &\quad - \zeta \left(I_{it} - I^{*}\right) + \varphi h_{I,t} + \gamma D_t \end{aligned} \tag{31b}$$

$$\begin{aligned} P_{it}^{'} &= P_{it-1}^{'} + \left[1 - \frac{d_t \left(1-\kappa\right)}{\left(1-\phi\right)}\right] \zeta \left(I_{it-1} - I^{*}\right) \\ &\quad - \left[1 - \frac{d_t \left(1-\kappa\right)}{\left(1-\phi\right)}\right] \varphi \delta_{MI,t-1}^{2} + \left(1-\lambda\right) C_{it} \\ &\quad + \frac{d_t \left(1-\kappa\right)}{\theta \left(1-\phi\right)} Q_{kt} - \left[1 - \frac{d_t \left(1-\kappa\right)}{\left(1-\phi\right)}\right] \gamma D_{t-1} \\ &\quad - \zeta \left(I_{it} - I^{*}\right) + \varphi h_{I,t} + \gamma D_t \end{aligned} \tag{31c}$$

$$
\begin{aligned}
\Delta P_{it}^{'} &= (1-\lambda)\,C_{it} + \frac{d_t\,(1-\kappa)}{\theta\,(1-\phi)}Q_{kt} \\
&- \left[1 - \frac{d_t\,(1-\kappa)}{(1-\phi)}\right]\varphi\delta_{MI,t-1}^{2} \\
&+ \left[1 - \frac{d_t\,(1-\kappa)}{(1-\phi)}\right]\zeta\,(I_{it-1} - I^{*}) \\
&-\zeta\,(I_{it} - I^{*}) + \varphi h_{I,t} \\
&- \left[1 - \frac{d_t\,(1-\kappa)}{(1-\phi)}\right]\gamma D_{t-1} + \gamma D_t
\end{aligned} \tag{32}
$$

Finally the variation of price hard/hard currency is described as :

$$
\begin{aligned}
\Delta P_{it}^{'} &= (1-\lambda)\,C_{it} + \frac{d_t\,(1-\kappa)}{\theta\,(1-\phi)}Q_{kt} \\
&- \left[1 - \frac{d_t\,(1-\kappa)}{(1-\phi)}\right]\varphi\delta_{MI,t-1}^{2} \\
&+ \left[1 - \frac{d_t\,(1-\kappa)}{(1-\phi)}\right]\zeta\,(I_{it-1} - I^{*}) \\
&-\zeta\,(I_{it} - I^{*}) + \varphi h_{I,t} \\
&- \left[1 - \frac{d_t\,(1-\kappa)}{(1-\phi)}\right]\gamma D_{t-1} + \gamma D_t
\end{aligned} \tag{33a}
$$

$$
\begin{aligned}
\Delta P_{it}^{'} &= (1-\lambda)\,C_{it} + \frac{d_t\,(1-\kappa)}{\theta\,(1-\phi)}Q_{kt} + \frac{d_t\,(1-\kappa)}{(1-\phi)}\varphi\delta_{MI,t-1}^{2} \\
&+ \left[1 - \frac{d_t\,(1-\kappa)}{(1-\phi)}\right]\zeta\,(I_{it-1} - I^{*}) \\
&-\zeta\,(I_{it} - I^{*}) + \varphi\left(h_{I,t} - \delta_{MI,t-1}^{2}\right) \\
&- \left[1 - \frac{d_t\,(1-\kappa)}{(1-\phi)}\right]\gamma D_{t-1} + \gamma D_t
\end{aligned} \tag{33b}
$$

$h_{I,t} - \delta_{MI,t-1}^{2}$ measures the expected volatility described as $GARCH(1,1)$.
As the past volatility have no effect in variation of price, the
$\left[\frac{d_t(1-\kappa)}{(1-\phi)}\varphi\delta_{MI,t-1}^{2}\right]$ is eliminated.
Hence, the variation of price hard/hard currency can be written as :

$$
\begin{aligned}
\Delta P_{it}^{'} &= \beta_0^{'} + \beta_1^{'} C_{it} + \beta_2^{'} Q_{kt} + \beta_3^{'} I_{it} + \beta_4^{'} I_{i,t-1} \\
&\quad + \beta_5^{'} D_t + \beta_6^{'} D_{t-1} + \beta_7^{\prime} JNAD + \varphi \delta_{aMI,t}^{2}
\end{aligned} \tag{34}
$$

With

$$
\begin{aligned}
\beta_1^{'} &= \frac{\kappa\left(1-\lambda\right)\left(1-\phi\right)}{\kappa-\phi} \\
\beta_2^{'} &= \frac{\left(1-\kappa\right)}{\theta\left(\kappa-\phi\right)} \\
\beta_3^{'} &= -\frac{\left(1-\phi\right)}{\left(\kappa-\phi\right)}\zeta \\
\beta_4^{'} &= \zeta \\
\beta_5^{'} &= \frac{1-\phi}{\kappa-\phi}\gamma \\
\beta_6^{'} &= -\gamma
\end{aligned}
$$

Our baseline model is :

$$
\begin{aligned}
\Delta P_{it} &= \beta_0 + \beta_1 C_{it} + \beta_2 Q_{jt} + \beta_3 Q_{kt} + \beta_4 \Delta P_{it}^{'} + \beta_5 I_{it} \\
&\quad + \beta_6 I_{i,t-1} + \beta_7 D_t + \beta_8 D_{t-1} + \beta_9 JNO + \rho \Delta SP_t + \epsilon_{it} \\
\Delta P_{it}^{'} &= \beta_0^{'} + \beta_1^{'} C_{it} + \beta_2^{'} Q_{kt} + \beta_3^{'} I_{it} + \beta_4^{'} I_{i,t-1} \\
&\quad + \beta_5^{'} D_t + \beta_6^{'} D_{t-1} + \beta_7 JNAD + \varphi \delta_{aMI,t}^{2} + \epsilon_{it}
\end{aligned} \tag{35}
$$

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