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Abstract

In a basket managed foreign exchange rate arrangement, the volatility of the domestic money should exhibit a particular pattern: (1) it is reduced due to the diversification effect by linking the domestic money to a portfolio of currencies and frequent interventions of policymakers, (2) it reflects the variability of each component in the basket. Consequently, if there exists a significant foreign exchange exposure to hedge, this will be a multidimensional exposure. In a basket arrangement, two main relevant questions arise: to hedge or not to hedge? And if hedging is a worthwhile decision, what type of financial instrument should be used to offset the currency risk? Different hedging strategies are proposed and compared to the unhedged strategy. Reconstituted data on basket option hedging as a direct policy implication of the basket foreign exchange arrangement is also included and compared to the overall hedging strategies. Given the nonlinear payoff structure of some hedging strategies we implement a performance comparison based extensively on non parametric distribution free approaches—the difference in the Sharpe Ratios with statistical inference based on the studentized circular block bootstrap method and Stochastic Dominance approach. Daily data on the Tunisian Dinar exchange rate against two major currencies, the EUR and the USD, and on currency call options written by the Central Bank of Tunisia spanning the period from January 1999 to December 2005 is the basis of our empirical evidence. It is shown that the choice of the hedging instrument depends on the currency of denomination and the hedging horizon, and that the basket option is frequently ranked (in 88% of the cases) as the adequate strategy.

ملخص

في أي ترتيب يقوم على سلة عملات بأسعار العملات الأجنبية، نجد أن تقلب أسعار العملات المحلية ينبغي أن يظهر نموذجا معينا: -1 يتسم هذا التقلب بالهدوء نظرا لارتباط العملة المحلية بسلة من العملات مما يتيح قدرا من تنوع التأثيرات لما يعهد إليه صناع السياسات من تدخل مستمر. -2 يعكس ما يتعرض له كل عنصر من عناصر تلك السلة من قابلية للتغير. ومن ثم نجد أن في حالة وجود تعرض مهم بالنسبة للعملات الأجنبية للحماية، فان هذا التعرض سيكون متعدد الأبعاد. كما نجد انه في حالة وجود ترتيب يقوم على سلة عملات فأنه يطرح على الساحة سؤلان رئيسيان وثيقا الصلة بالموضوع وهما: هل تفرض حماية للعمة المحلية أم لا، فإذا كان قرار الحماية جديرا بالاهتمام ، ما هو نمط الأداة المالية التي ينبغي استخدامها لإحداث التوازن عند تعرض العملة للمخاطر؟ وتقترح أساليب مختلفة للحماية ويقارن بينها وبين الأسلوب الرافض للحماية كما يشمل ذلك أيضا إعادة تشكيل البيانات الخاصة بالحماية القائمة على خيار السلة باعتبار ذلك من أثار السياسة المباشرة للترتيب القائم على سلة عملات ويشمل أيضا مقارنة ذلك بغيره من أساليب الحماية الشاملة. ونظرا لان بعض أساليب الحماية ذات بنية غير خطية تستخدم على نطاق واسع مقارنة الأداء القائمة على الأساليب التي تخلو من التوزيع غير القياسي: أي الفارق في نسبة شارب والاستقراء الإحصائي القائم على طريقة studentized circular block bootstrapوعلى أسلوب الهيمنة العشوائية. وقد اخترنا أساسا لأدلتنا التجريبية متثلاً في البيانات اليومية عن أسعار العملة للدينار التونسي في مقابل عملتين رئيسيتين هما اليورو والدولار الأمريكي. وعن خيارات طلبات العملة التي أعلنها البنك المركزي التونسي خلال الفترة من يناير 1999 وحتى ديسمبر 2005. وقد بينا أن خيار الأداة الحمائية يتوقف على العملة المسماة، وكذا على أفق الحماية وذلك الخيار المتعلق بالسلات (88% من الحالات) كثيرا ما يعتبر هو الأسلوب الأمثل.

Introduction

More than half of the IMF members are classified as following intermediate exchange rate regimes that are somewhat in between a free float and a hard peg. Intermediate regimes include target zones, crawls, basket pegs or a combination of them. These exchange rate arrangements are characterized by frequent interventions from policymakers to influence the level and the volatility of the exchange rate. The government's choice of an international monetary arrangement could affect the financial decisions of private individuals and firms, the demand of financial risk management instruments and the dynamics of the exchange rate. Studies of the institutional arrangements' effect on these variables have focused mainly on two types of exchange rate systems: the floating and the target zone regimes (Krugman, 1991; Dumas et al., 1993, 1995; Dillèn, 1994). To our knowledge, the intricacies of a basket arrangement have not been dealt with adequately in the financial literature. In this paper, we examine the hedging decisions of a financial operator when the domestic currency is linked to a bundle of currencies. We analyze the financial implications of the currency basket from a risk management viewpoint.

The volatility of the exchange rate depends primarily on the exchange rate regime (Flood and Rose, 1999)[1] and this in turn has an effect on how we deal with the hedging decision. For example, under the pure floating exchange rate system, if prices are perfectly flexible, they move by large amounts in response to new information on economic fundamentals. Economic agents bear a significant exchange rate exposure due to unpredictable events in the foreign exchange market. Under the pegged exchange rate system, theory suggests that this type of exchange rate arrangement leads financial operators to disregard currency exposure and reduce their hedging activities[2]. Under the target zone model, exchange rates are primarily driven by market forces within the upper and lower intervention bands. When the exchange rate hits the bands, its likely direction is easy to determinate. If the exchange rate hits the upper band, there exists a downward risk. If the exchange rate hits the lower band there exists an upward exposure.

When the domestic currency is linked to a basket of major currencies its volatility is reduced for at least two reasons: the diversification benefits by indexing domestic money to a portfolio of currencies (Mundaca, 1991; Jorion, 2001; Ogawa and Kawazaki, 2003; Ogawa and Shimizo, 2004), and frequent interventions from policymakers in the foreign exchange market (Dominguez, 1998; Flood and Rose, 1999; Watanabe and Harada, 2006)[3]. If the benefits of hedging rest upon the volatility of the exchange rate, then in a basket exchange rate system two relevant questions arise. Should financial operators hedge foreign exchange exposure? And if the decision to hedge is of relevance, what type of financial instrument should be undertaken to offset currency exposure?

We compare different strategies to hedge foreign account payables to the unhedged decision. The hedging strategies include reconstituted data on call basket options as a multi-risk hedging vehicle. Performance appraisal is based on an extensive use of non parametric bootstrap methods. In particular, we first focus on the first two moments of the distribution

[1] Flood and Rose (1999) formalized this stylized fact on a non-linear model with multiple equilibriums in which foreign exchange volatility is regime specific and does not depend on fundamentals' volatilities. Their argument holds for different specifications of exchange rate models (e.g., allowing for price sluggishness /stickiness…).

[2] See Dooley (2000) and Burnside et al. (2001).

[3] This argument may be viewed as counterintuitive. That is, if the anchor currencies are major floating currencies (e.g., EUR and/or the USD), which are considered here as volatile currencies, the base currency will also be volatile. But at the portfolio level, the correlation effect can overweight the single volatilities effect. Another argument is that volatility is shown to be regime-specific. Flood and Rose (1999) argued that non-floating countries exhibit lower exchange rate volatility than floating countries but have similar fundamental volatilities.

by testing the differences of the Sharpe Ratios of paired strategies (Wolf, 2007). Statistical inference uses the studentized circular block bootstrap procedure. We then extend the analysis to compare the whole overweight distribution functions of the hedging strategies using recent stochastic dominance bootstrap based test of Barrett and Donald (2003).

Empirical analysis is applied to the case of the Tunisian Dinar (TND). The value of the TND is determined as a weighted sum of a portfolio of currencies with a dominant Euro component. According to modern portfolio theory, by mixing currencies with low correlations to one another in the appropriate proportions, risk can be reduced at the portfolio level, despite the presence of volatile underlying currencies. To prevent the foreign exchange market from destabilizing speculation, Tunisian monetary authorities do not disclose the currencies and their corresponding weights and restrict capital account convertibility.

The layout of this paper is as follows: in the first section we present our dataset with a theoretical discussion of the interplay between the exchange rate system and the hedging decisions of financial operators. In section two, we examine the hedging strategies designed to protect against exchange rate fluctuations. In section three, we set the basket weights in a dynamic state space framework and estimate them using the Kalman (1960) recursion. In section four, we use the estimated weights to price a basket option using the Sobol low discrepancy sequence. An overview of performance measurement criteria is presented in section five and the analysis of the results is provided in section six.

1. Data Description

The empirical study is applied to the case of the TND. The choice of the TND as the basis of our empirical evidence requires a preliminary discussion of the Tunisian foreign exchange policy. The *de jure* Tunisian foreign exchange policy is a basket peg where neither the currencies nor their associated weights are disclosed. We rely on previous research (Bénassy-Quéré et al., 2004 and Yol and Baharumshah, 2005) and informal discussion with the Central Bank officials to assume that the currencies composing the TND basket are the EUR and USD. Recent works performed by Bénassy-Quéré et al. (2004) and Yol and Baharumshah (2005) confirms, *de facto*, this foreign exchange arrangement. The basket weights are roughly based upon the relative importance of Tunisia's trading partners. The European Union is the largest trade partner. Exports to the Euro-zone market account for almost 80% of total Tunisian exports. This places the EUR as the major invoiced currency in Tunisia's external transactions with almost 60% of the foreign exchange transactions in the Tunisian interbank market. The remaining transactions (about 39%) are typically settled in USD[4]. This exchange rate policy has ensured reasonable stability of the exchange rate and discouraged speculative activity as much as possible.

The data entails daily observations on the spot exchange rates TND/EUR, TND/USD, call options written by the Central Bank of Tunisia on the same currencies and interest rates on three, six and twelve months. Exchange rates of the TND against the EUR and USD and call option data is drawn from the Central Bank of Tunisia. Interest rates on the corresponding currencies are provided by the Bloomberg Financial Service. The data spans the period from 01/01/1999 to 30/12/2005 and is chosen to match the basket arrangement relatively closely[5] (subject to restrictions of data availability).

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[4] Given the discretion in setting foreign exchange policy, it is difficult to make a judgment about the relative weights of the basket components. Here, the difference between trade weighs and transaction weights could be explained by the dollarization of international payment flows (for example raw material trades are basically invoiced in USD) or capital account transactions.

[5] Recently, much concern has risen in favor of gradual transition from the basket exchange rate regime towards a hard peg to the EUR and full convertibility of the TND.

Options written by the Central Bank of Tunisia are non-tradable at the money European calls for maturities of three, six and twelve months. Typically there are no transactions on options since their introduction in 1989. The luck of expertise, the cost of option hedging and the reduced volatility of the exchange rate explain the reluctance of financial operators to purchase options for hedging motives (Abid and Habibi, 2001). With a transaction volume that accounts for almost 20% of the spot transactions, the forward contracts are typically the main hedging instrument used by Tunisian firms. Forward contracts on EUR and USD have begun trading in the OTC market since 1997.

Figure (1) plots historical data for the TND/EUR, TND/USD and EUR/USD spot exchange rates.

In the short term, the TND exhibits significant fluctuations against both the EUR and the USD. In the long run, we depict a tendency of the TND to depreciate against the EUR. This exchange rate policy is frequently pursued by small open economies to boost exports and enhance the trade balance. The TND/USD and the EUR/USD exchange rates move in tandem. An appreciation episode of the EUR against the USD corresponds to a comparable appreciation of TND against the USD and vice-versa. We expect that the EUR has the preponderant weight in the basket and is thereby the leading currency for the TND.

A basket currency arrangement could be depicted by comparing the volatility of a basket exchange rate to that of a floating currency (Engel and Hakkio, 1993; Bénassy-Quéré, 1996). Figure (2) displays the one month historical volatilities[6] of the TND/EUR and the TND/USD exchange rates compared to a benchmark floating currency, the EUR/USD.

Figure 2 supports several conclusions on the foreign exchange volatility. First, the volatility of the floating exchange rate is significantly higher than the volatility of the TND with respect to the EUR and USD. Second, the volatility of the TND/EUR is less than the TND/USD, averaging for 0.24% and 0.475%, respectively. This TND/EUR reduced volatility pattern can be explained by Tunisian authorities' intentions to maintain the stability of TND against the EUR given that the bulk of Tunisia’s external trade is with the European Union. In this context, financial literature has provided support that public intervention could dampen excessive volatility (Dominguez, 1998; Flood and Rose, 1999; Watanabe and Harada, 2006).

Since 1986, fundamental structural reforms have been implemented to ensure a gradual integration into the global economy. As a result of this process the TND has been convertible on the current account since June 1993. Recently, substantial relaxation of foreign exchange controls has been established and many interest rate and currency risk management instruments have been introduced in the Over-The-Counter (OTC) market in the process towards a full convertible TND. Given this exchange rate policy, it is worth reexamining the debate on hedging versus non-hedging decisions and the question of choosing the appropriate hedging vehicle.

2. Strategies for Hedging Transaction Exposure

In what follows we examine the effectiveness of some foreign exchange hedging decisions. These strategies include: Hedging using forward contracts (FRet), hedging using call options (OptRet), the unhedged strategy (NhgRet), three selective hedging strategies (RwRet, TFRet and TOptRet) and hedging using reconstituted data on call basket option (BRet). We focus

[6] Historical volatility is calculated as the standard deviation of percentage changes of daily logarithmic returns over a one month sample period. We construct a time series of historical volatility based on a rolling window of one month length. So if the whole sample returns N observations and the window length is equal to m (with $N \geq m$), we get a sample of $N - m + 1$ historical volatilities.

only on hedging foreign account payables[7]. This includes trade account payables, principal and interest payables, etc…The evaluation criteria are typically stated in terms of rate of returns[8].

2.1. Forward hedging

Hedging foreign payables in the forward market requires taking a long position on a forward contract. This forward contract will move into profit or loss based on exchange rate movements. If the forward exchange rate at the settlement date exceeds the spot exchange rate, the long forward hedger incurs an opportunity cost equal to the difference between the spot and the forward exchange rate. In the opposite case, the position will be locked at a gain.

2.2. Call options hedging

Call options can be used to limit the upward side exposure while preserving the ability to take advantages of the downward exposure but at the cost of the initial premium given to the option writer. Theoretically, in order to ensure a zero net exposure, an option strategy requires continual portfolio rebalancing. In practice, transactions costs, expertise, non-convertibility and other impediments preclude investors to manage their option position. As noticed above, we use the money call options written by central bankers as a hedging vehicle for EUR and USD denominated payables.

2.3. Unhedged strategy

It is now widely reported in financial literature that a substantial risk reduction can be achieved via the adoption of a foreign exchange rate basket arrangement (Ogawa and Shimizo, 2004; Ogawa and Kawazaki, 2003; Jorion, 1991). Based on this argument, we investigate the usefulness of the unhedged position.

The change in the spot exchange rate could be considered a measure of the influence of currency fluctuation on the foreign exchange position. If the exchange rate remains unchanged, then exchange rate risk has no effect on foreign exchange positions. In contrast, an appreciation (depreciation) of the foreign currency will induce a loss (gain).

2.4. Selective hedging strategies

Selective hedging was first proposed by Stulz (1996). This approach gives an active role to the manager's expectations regarding the future evolution of the exchange rate. In this paper, we propose to examine two selective hedging strategies: (a) the random walk model and (b) the trend model. These strategies draw on theoretical arguments and empirical finding on the dynamic of the exchange rate.

2.4.1. The Random Walk Model

This strategy is based on the empirical finding that the appropriate model of exchange rate dynamics is the simple random walk (Giddy and Dufey, 1975; Meese and Rogoff,1983; Chiang, 1986 and Alexander and Thomas,1987). The random walk model predicts that the best estimation of the future exchange rate is simply the current exchange rate. Under this model the decision to hedge foreign payables should be undertaken whenever the forward exchange rate is at a discount, $F < S_t$. Eaker and Grant (1990) and Eun and Resnick (1997) have shown that, for floating currencies, the random walk selective hedging strategy outperforms many hedging strategies of international portfolio investments. An important issue arises whether the random walk hedging rule could be extended to a foreign exchange market characterized by frequent interventions of public authorities.

[7] Given that only call options exist in the Tunisian foreign exchange market.

[8] See Abid and Habibi (2008) for a detailed exposition of the hedging strategies' returns.

The random walk hypothesis supports the weak form efficiency that existing exchange rates reflect all the relevant information contained in past price changes. Under this hypothesis, there exist no simple trading rules based upon past price changes that would allow traders to reap unusual profit. Theoretical studies (Bhattacharya and Weller, 1997) and the experience with the target zone arrangement show that the underlying reason for the systematic profit of speculators was that the rules for interventions were roughly known. In a managed exchange rate arrangement, there are few if any signs that indicate the mechanism of foreign exchange intervention. Furthermore, transaction costs and asymmetric information induced by central bank interventions preclude traders to undertake speculative operations. This is because the gross profit on offer does not offset the speculative costs, which ensure market efficiency in the sense of Jensen (1978). Therefore, it is more likely for the random walk model of exchange rate behavior to hold in a managed exchange rate system than in a floating exchange rate system.

2.4.2. The Trend Model

In this selective hedging strategy, the trend rule, the hedger is assumed to have "bandwagon expectations" and tries to forecast the exchange rate by extrapolating the recent trend in the exchange rate. It is essentially a technical trading rule. Under this hedging rule, the decision to hedge foreign exchange payables is undertaken whenever the recent exchange rate direction is an upward trend. Furthermore, the increase in the exchange rate should be sufficiently large to cover the forward premium or the option premium. This strategy can be extended to include a moving average of recent trends if the trend is not clearly discernable. We examine forward and currency call hedging decisions under the trend rule. If the exchange rate moves downward, then foreign exchange payables are kept unhedged. Take for example the three months TND/EUR hedging. If during the last three months the TND/EUR exchange rate increases to a level that surpasses the option premium, then the decision to hedge (TOptRet) is undertaken for the next three months. Otherwise (that is a decrease or increase that does not exceed the option premium) the foreign exchange position is kept unhedged.

The random walk behavior of exchange rate does not mean that there is no trend in the exchange rate. Exchange rate is driven by fundamentals such as relative prices, interest rate differentials, relative money demand, etc... If these fundamentals move in its predictable trend, then this is the case for the exchange rate. However, exchange rate changes around these trends are random and unpredictable. However, the Fisher effect predicts that the interest rate differential prevents traders from systematically exploiting these trends for speculative profits.

2.5. Hedging using a basket option

A European currency basket option is a contingent claim written on a portfolio of correlated currencies. We use reconstituted data on call basket options to compare its performance with respect to the preceding hedging strategies. The rational for using the basket option is that the basket arrangement exposes investors to multiple sources of uncertainties due to the variability of each component in the basket. To cope with this multidimensional risk, the basket option is an appropriate hedging instrument (Gentle, 1993). Consistent with the practice of monetary authorities in writing plain vanilla options, we use only the money style call basket options. Estimated basket weights from available spot exchange rate data are used to price call basket options.

The use of estimated weights is also consistent with the definition of foreign exchange exposure advocated by Adler and Dumas (1984). Accordingly, a firm’s exposure to foreign exchange could be measured by the sensitivities (weights) of the local currency cash-flows to the overall basket components.

3. State Space Modeling of the Basket Exchange Rate Arrangement

The general approach in modeling the exchange rate is to express its value as a function of some fundamentals. This approach is modulated to account for the exchange rate system. For instance, in the target zone model introduced by Krugman (1991), the exchange rate varies to reflect the agent's expectations about some fundamentals and the exchange rate system feature is accounted for by letting the exchange rate changes be zero when the exchange rate hits the edges of the band. Within a basket peg exchange rate system, economic fundamentals offer little guidance in estimating the exchange rate.

The methodology used to assess a basket pegging is credited to Frankel and Wei (1994). It expresses the value of the local currency as a linear combination of the values of the reference currencies. Econometric modeling is as follows:

$$S_{0,t} = \alpha_{0,t} + \sum_{i=1}^{d-1} \alpha_{i,t} S_{i,t} + \varepsilon_t \quad (1)$$

$S_{0,t}$ is the time t exchange rate of the home currency with respect to the numeraire 0, $S_{i,t}$ is the time t exchange rate of the currency i with respect to the same numeraire, $\alpha_{0,t}$ and $\alpha_{i,t}$ are, respectively, the weights of the numeraire and currency i in the basket. Here the basket is assumed to contain d currencies. In a strict basket pegging system, the error term can be omitted from equation (1). However, in practice, public authorities intervene in the foreign exchange market if they perceive that the exchange rate is misaligned with respect to fundamentals or if the volatility is too excessive. Even in the Bretton Woods system, exchange rates are allowed to change within a $\pm 1\%$ band around the official parity.

Previous studies have assumed that weights are constant over time and applied OLS estimation to infer the basket weights (Frankel and Wei, 1994; Cavoli and Rajan, 2005; Bénassy-Quéré, 1999; Frankel et al. 2001; Galati, 2001; Ohno, 1999). However this methodology is inconsistent with the theory of optimal basket peg (Flander and Helpman, 1979) and the practice of central bankers. In a managed basket foreign exchange rate regime, basket weights are important policy tools to implement policy goals that change over time. Thereby, a flexible specification that could handle both changing features of the coefficients and possible unit root behavior of the exchange rate data is more consistent with macroeconomic theory and policy practice than standard specification models.

We propose to estimate the weights using the state space modeling and the associated Kalman (1960) recursion. This approach is useful to formulate models that are much wider and richer than conventional models (Engle and Watson, 1987; Harvey, 1987).

The state space model with changing coefficients that corresponds to equation (1) takes the form (Harvey, 1987; 1989; Hamilton, 1994):

$$y_t = G_t \alpha_t + \omega_t \quad (2)$$

$$\alpha_{t+1} = F_t \alpha_t + \upsilon_{t+1} \quad (3)$$

For economic reasons, the model in (3) takes the coefficients as non observed and time dependent and gives estimates of the coefficients at different points of time. It is generally assumed that basket weights are governed by a first order Markov process as described by equation (3).

4. Pricing Currency Basket Options with Quasi-Monte Carlo Method

The problem of estimating the value of a currency basket option consists of solving a multidimensional stochastic integral where the dimension is equal to the number of currencies included in basket. By assuming that the basket is comprised by d correlated lognormally distributed exchange rates, we cannot derive an analytic solution for the price of the basket option. This is because there is no explicit formula for the probability density function of the sum of d correlated lognormal processes. Quasi-Monte Carlo is a powerful numerical method for dealing with the pricing of multidimensional contingent claims. Instead of generating random variates for numerical integration as with the standard Monte Carlo method, Quasi-Monte Carlo proceeds with the use of deterministic sequences or sequences of low discrepancy. The discrepancy of points is a measure of the uniformity of points in the unit hypercube domain. The more uniform the points are, the less the discrepancy is. Increased uniformity results in an improved convergence rate of the Quasi-Monte Carlo method ($O(\frac{1}{N})$ or even $O(\frac{1}{N^{3/2}})$) over the standard Monte Carlo Method ($O(\frac{1}{\sqrt{N}})$) (Caflisch and Morokof, 1996; Owen, 1997).

Figure (3) displays the distribution of points in the unit cube domain using a random numbers generator and the Sobol low discrepancy sequence. Points used by the Sobol sequence are more uniform than points picked from a random number generator. New added points, for the case of the low discrepancy points, progressively fill the gap between previous points. In the case of the random number generator, points newly generated, use to cluster. The implications of pricing in a basket option are straightforward. We know that the fair price of a basket option can be estimated by integrating, numerically, its payoffs at maturity (Boyle et al. 1997). If the numerical integration is performed using a random number generator this will cause a pricing bias. If, instead, a low discrepancy sequence is used to integrate the payoffs of the option, its estimated price will converge to the true value. That is, the pricing error decreases as long as the discrepancy of points decreases.

The most familiar sequences used in the pricing of multidimensional contingent claims are the Sobol, Halton and Faure sequences (Boyle et al. 1997). Based on empirical findings that the Sobol method outperforms the basic Monte Carlo and many deterministic sequences for pricing multidimensional contingent claims (Kocis and Whiten, 1997; Paskov and Traub, 1995), we use this sequence to price a currency call basket option.

As with the Garman and Kohlhagen (1983) model we assume that interest rate parity (IRP) holds. This hypothesis seems to be too simplistic in the context of a managed exchange rate regime, but there exists theoretical rationale to hold such an arrangement.

Violations of the IRP are essentially explained by the existence of a risk premium. In a floating world, investors will require a risk premium on a future transaction compared to a forward transaction whenever the volatility of the exchange rate exceeds that of the fundamental determinant. The experience with the floating exchange rate shows that supply and demand for currencies is purely generated by expectations of future exchange rates or destabilizing speculations. Under these circumstances, currency fluctuations will significantly exceeds the volatility of its determinants. Transactions costs, security transaction taxes, restrictions on capital flows and discretionary foreign exchange policy will discourage destabilizing speculation in the foreign exchange market. In such a context the volatility of the exchange rate will be reduced and domestic and foreign assets will be perfect substitutes. In a managed foreign exchange regime there are no reasons that justify the demand for a risk premium to exchange a domestic risk free asset by a foreign risk free asset. A recent empirical research pioneered by Bansal and Dahlquist (2000) indicates that IRP differ across developed and emerging market and tends to hold more frequently in emerging markets.

Flood and Rose (1996) show that departures from IRP are more significant in floating rate data than in fixed rate data. Furthermore, practical experience with currency crises in emerging markets shows that the transition towards floating regimes has contributed to more volatile currencies, systematic risk and risk premium.

5. Performance Measurements of the Hedging strategies

The traditional performance measurements are based on the mean variance approach of portfolio selection. This approach assumes that all economic behaviors are depicted by one static quadratic utility function, described by a well shaped distribution, in an idealized market. By virtue of the separation theorem, an individual's choice between risky prospects will be independent of his preferences towards risk. In the real word, market expectations about future prospects are not symmetric and the process by which information is reflected in security prices is not linear, which results in a departure from the normality hypothesis (Fama, 1965; Mandelbrot, 1963, 1967; Singleton and Wingender, 1986). Similarly, economic agent preferences are not as symmetric or as static as the quadratic utility hypothesis assumes (Sarnat, 1974). To circumvent these empirical irregularities, we propose to compare the different hedging strategies on the basis of non parametric performance criteria. Specifically, we perform a bitwise comparison of the hedging strategies by testing first the differences of the Sharpe Ratios using the recent bootstrap based methodology of Wolf (2007) and second the existence of stochastic dominance relationships in their distribution functions using Barrett and Donald (2003) bootstrap based test.

The test proposed by Wolf (2007) consists of constructing a studentized block bootstrap confidence interval for the difference between the Sharpe Ratios. If zero is not contained in the obtained interval then the two Sharpe Ratios are declared statically different. The confidence interval is then inverted to obtain the corresponding p-values. Resampling procedure uses the block bootstrap procedure to capture cross-sectional and serial correlations characterizing time series data. We compute the p-values based on 10000 bootstrap replications[9]. The bootstraps are based on recentered paired bootstraps with overlapping blocks of size $b = \alpha\left[\sqrt{T}\right]$ where $\left[\sqrt{T}\right]$denotes the largest integer that is less than or equal to $\sqrt{T}$. Following Lim et al. (2006) we compute the p-values based on α=2. The argument holds for a wide range of reasonable values of α .

Stochastic dominance (SD) is a non-parametric approach used to order choices among different risky prospects when preferences and/or asset return distributions are not precisely known. It incorporates information beyond the first two moments of the normal distribution and enables one to investigate a large class of utility functions. In general, three degrees of stochastic dominance rules are frequently examined in the financial literature: first order (SD1), second order (SD2) and third order (SD3) stochastic dominance rules (Hadar et Russel, 1969; Hanoch et Levy, 1969; Rothschild et Stiglitz,1970; Whitmore, 1970). Each degree corresponds to a specific class of utility function. Recently, different econometric tests have been developed to assess the statistical significance of various stochastic dominance relationships. In this paper we implement the Barrett and Donald (2003) bootstrap test of stochastic dominance in order to compare multiple integrals associated with the distributions of the different hedging strategies. Others previous tests of stochastic dominance, proposed by Anderson (1996) and Davidson and Duclos (2000), compare the distributions of competing strategies on arbitrary chosen points. This could lower the power of the test if there is a violation of the inequality imposed by the null on some subinterval lying between the evaluation points used in the test. The advantage of the Barrett and Donald (2003) is that

[9] We only report the results for the hedging strategies ranked according to the Sharpe Ratio. The test is transitive for all pairwise combinations (i.e. if strategy A dominates strategy B and B dominates C then A dominates C). We do not test for the case where the Sharpe Ratio is negative.

it compares the distribution at all points in the sample. Linton et al. (2005) propose a sub-sampling approach to test stochastic dominance instead of the bootstrap based test in order to capture serial dependence in time-series data. However, empirical comparison shows that the test yields similar results to the Barrett and Donald (2003) test (Abhyankar et al. 2006).

6. Result Analysis

6.1. Performance based on the Sharpe Ratio

Table (1) and (2) give some descriptive statistics on the hedging strategies. The means and standard deviations vary widely across the currency of denomination, the hedging strategy and the hedging horizon.

The basket option hedging strategy exhibits a positive return that increases with the hedging horizon. Furthermore, this strategy has the lowest variance for all maturities. This can be explained by the diversification effect induced by the basket exchange rate arrangement.

For the case of the TND/EUR, the returns from the forward and option hedging strategies are positive and increasing function of the hedging horizon. By contrast, unhedged foreign exchange payables produce negative returns that decline sharply as the hedging period increases. This finding can be explained by the tendency towards a devaluation of the Dinar with respect to the EUR. The devaluation pattern is visible in Figure (1) and becomes more pronounced in the long run. This exposes investors to a certain upward exposure that should be better hedged. Among the selective hedging strategies, the forward hedging based on the trend model becomes appropriate for a hedging horizon of 12 months. The return from the unhedged strategy is equal to the return from the random walk selective hedging strategy. High interest rate differential between the TND and the EUR, regularly keep the forward exchange rate at a premium and thus the decision to not hedge in the random walk model.

For the case of the TND/USD exchange rate, options and forwards are appropriate hedging vehicles only for short maturities. As long as the hedging horizon increases, unhedged USD denominated payables give a more attractive return structure. Nonetheless, the unhedged strategy exhibits a high volatility. If the hedging horizon is three months, active hedging that exploits the trending character of the exchange rate becomes interesting. In the selective trend model the investor hedges his USD denominated payables using options or forwards in 50% of the cases.

For all currencies and hedging strategies, the normality assumption is strongly rejected by the data as it is shown by the extended Kolmogorov-Smirnov statistic. This could induce systematic bias if the Sharpe Ratio is used for performance assessment (Lin and Chou 2003). To overcome this problem, we propose to test the differences of the Sharpe Ratios using the recent statistical methodology proposed by Wolf (2007).

6.1.1 Hedging EUR denominated payables

Table (3) shows that the basket option exhibits the higher Sharpe Ratio for the three and six month hedging horizons followed by the forward then the option strategies. The difference between the basket option and the forward hedging strategies is statistically significant with p-value equal to 0.561 and 0.775 in the three and six months hedging periods, respectively. Although the difference in performance between forward and option strategies is quite large for the three-month hedging horizon, the calculated p-value indicates that it is not statistically significant.

When the hedging period lengthens, the difference in performance between the basket and the forward hedging strategies diminishes. For the twelve-month hedging horizon, forward hedging strategy outperforms call basket option hedging. This is explained by the apparent devaluation of the TND against the EUR and the reduced volatility of the TND/EUR exchange rate. If investors are certain that monetary authorities will devalue the home currency in the long run, and if the interest rate differential doesn't compensate for the devaluation percentage, they will be reluctant to pay a higher option premium to hedge their foreign exchange exposure. Furthermore, government intervention to support the devaluation increases the payoff of the option at maturity which in turn tends to enhance its value and the cost of option hedging. Abid and Habibi (2001) show that, in a managed foreign exchange rate regime, options' underwriting should be severely out of the money to keep option hedging as attractive as forward hedging.

Unhedged EUR denominated payables exhibit the worst performance due to the devaluation effect of the TND with respect to the EUR.

6.1.2. Hedging USD denominated payables

Table (4) shows that for the shorter maturity it is more appropriate to hedge USD denominated payables with vanilla call options. For six and twelve month maturities, call basket options offer significantly higher Sharpe measure. Forward hedging is not appropriate whatever the maturity. Investors perceive a higher variability in both directions of the TND/USD exchange rate and are willing to pay the option premium to protect themselves against this two-sided variation. All differences in the Sharpe Ratios between consecutive strategies are significant at the standard 5% level.

6.2. Stochastic dominance results

We apply Barret and Donald (2003) stochastic dominance test that compares the distributions of the hedging strategies at all points in the return range. The authors propose varieties of simulation and bootstrap based tests to estimate the exact p-value. In general the different sampling schemes provide comparable results, but the authors recommend bootstrap based tests (KSB1 in the authors' notation) which have great power to detect any violation of the null hypothesis.

6.2.1. Hedging EUR denominated payables

Table (5) shows bootstrapped p-values for bitwise comparison of the hedging strategies.

For a three month hedging horizon, call basket option stochastically dominates all the other hedging strategies. Compared to the existing hedging strategies (forward and options), call basket hedging is appropriate for risk averse behaviors. The reverse ranking is clearly rejected by the data. That is, no strategy seems to dominate basket options. This result is consistent with the Sharpe Ratio classification. For maturities of six and twelve months no dominance was detected between basket and forward hedging strategies. This ranking disagrees with the Sharpe classification where forward significantly outperforms basket options.

The null of dominance of forward over vanilla option is rejected for the first and second order for the three month horizon but weak evidence for the third order dominance is found. The dominance of forwards becomes more obvious for longer hedging horizons.

Consistent with the Sharpe criterion, stochastic dominance shows that not hedging is the worst strategy for all maturities. Abid and Habibi (2001) reported opposite results in the case of the TND/FRF and TND/DEM exchange rates. They show that, whatever the hedging horizon, the unhedged strategy exhibits the highest Sharpe measure. Where the devaluation of the TND has been smoothly diluted with respect to an extended basket of European currencies in the pre-euro era, it has been focused sharply on a single currency since the introduction of the EUR. This sharp devaluation of the EUR explains the supremacy of all hedging strategies against the unhedged one. Selective hedging seems to be inadequate for the TND/EUR case.

6.2.2. Hedging USD denominated payables

In case of the three months hedging, Table (6) shows that plain vanilla and basket options are the best hedging instruments. As the hedging horizon lengthens, basket option proves its supremacy compared to all other strategies. In the six months hedging strategy, the random walk model ranks second according to the SD criteria.

Recall that selectively hedging by exploiting the random walk character of the exchange rate consists of hedging only when the forward rate is at a discount. Under this model, the decision to hedge is taken only at the beginning of the period (from January 2000 to January 2001) which corresponds to almost 20% of the whole period. The decision to not hedge USD denominated payables at the beginning of the year 2001 can be explained both by the rise of the USD/EUR exchange rate after the concerted intervention of industrialized central banks at the end of 2000 and the increase of the EUR-USD interest rate differential in March 2001.

For the twelve months case the unhedged strategy ranks second. This finding can again be explained by the rise of the EUR with respect to the USD, on average, in the long run.

Forwards, the commonly used hedging instrument by Tunisian firms, are inadequate in the case of TND/USD hedging. Indeed, all hedging strategies dominate the forward hedging for all investment horizons.

We should mention that during the period of study, the US consistently devalued the dollar with respect to the euro, which explains the asymmetrical results between euro versus dollar hedges.

Conclusion and Policy Implications

Choosing an exchange rate regime has a significant effect on the volatility of the exchange rate and, consequently, on many financial decisions. Apart from the floating and target zone models, intermediate exchange rate arrangements have not adequately been studied in financial literature. Our contribution in this paper consists of examining the influence of the exchange rate arrangement on the hedging decisions of financial operators. We focus on the case of a basket exchange rate arrangement. When the domestic currency is linked to a bundle of currencies, financial operators bear a multidimensional risk due to the volatility of each component in the basket. Correlation between the exchange rates with respect to a given numeraire exerts a smoothing effect of the volatility of the basket as a whole. Consequently, the challenging question of whether or not to hedge and which hedging instrument is more adequate arises. Several strategies to hedge foreign account-payables are proposed and compared on the basis of the Sharpe Ratio and stochastic dominance approaches. Based on the multidimensional feature of risk in a basket exchange rate arrangement, we propose to study the performance of currency basket options on the basis of reconstituted data where the currency weights are those estimated using the Kalman filter. Empirical evidence is applied to the case of the Tunisian Dinar against the EUR and the USD for the period January 1999 to September 2005.

Various order stochastic dominance rules are depicted for the different hedging strategies. The main finding is that call basket options stochastically dominate existing hedging strategies and all selective hedging strategies in 88% of the cases and is not dominated by any of the hedging strategies.

Our finding has direct theoretical and practical financial implications. First, public commitments to policies consistent with the stabilization of the exchange rate have a critical effect on the choice of the hedging techniques. A universal hedging instrument for all foreign exchange contexts or all hedging horizons does not exist. In formulating his hedging strategy, the manager should take into account the existing monetary and foreign exchange policy. For example a policy transition towards a free float or a single currency peg could shift the return distribution of the different hedging strategies and, thereby, the choice between them.

Second, government regulations with regards to foreign exchange can alter the relative cost of some financial instruments; it can act as an incentive towards new and innovative financial hedging techniques with a better risk return tradeoff. Third, it is possible to enhance the cost effectiveness of hedging activities using derivatives written on a portfolio of assets. As the risk manager may bear different financial risks such as currency risk, interest rate risk and commodity risk simultaneously, a significant cost reduction could be achieved by using derivatives on a portfolio of assets instead of hedging risk exposure separately. Over-the-counter financial industry offers investors a wide range of financial instruments (such as heterogeneous basket options) tailored to fulfill this objective.

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Figure 1: Spot Exchange Rates TND/EUR, TND/USD, EUR/USD

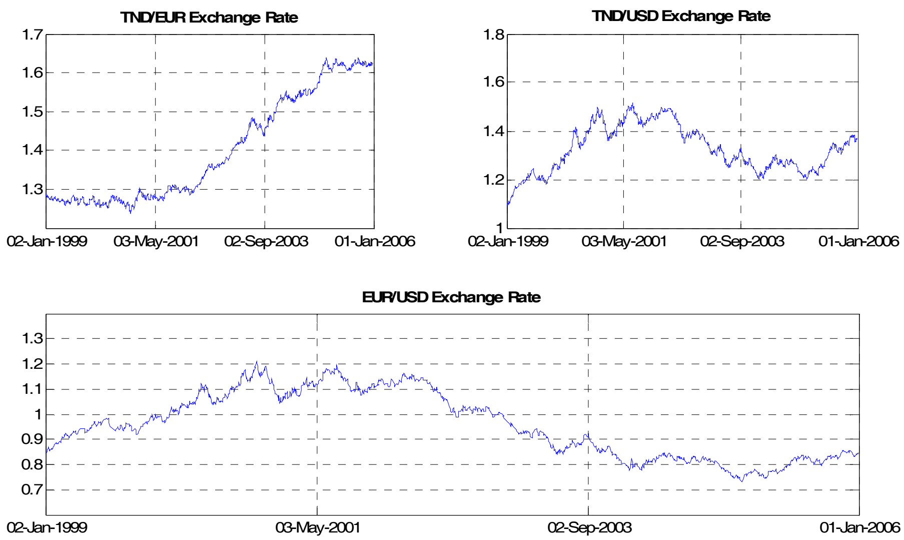

Figure 2. One Month Historical Volatility of the TND/EUR TND/USD and EUR/USD

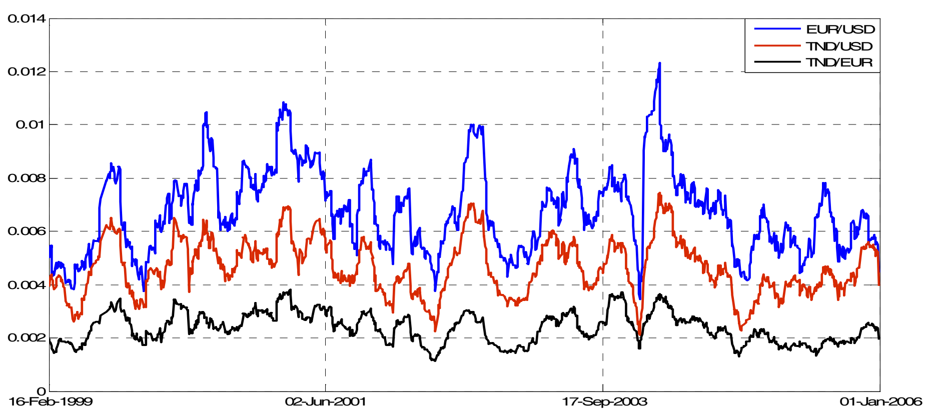

Figure 3. Distribution of the Sobol vs. Random Points in the $[0,1]\times[0,1]$ Rectangle

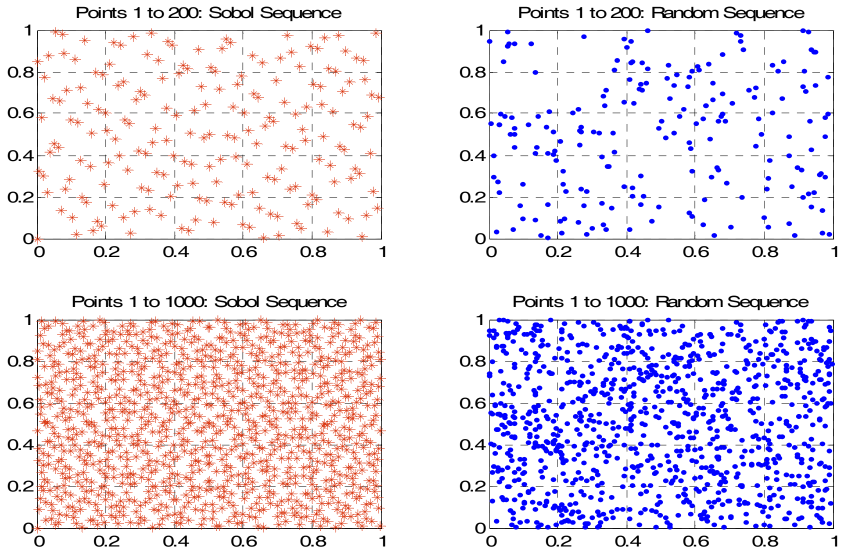

Table 1. Descriptive Statistics for TND/EUR Hedging Strategies

	FRet			***OpRet***			***NhgRet***			***RWRet***			***TFRet***			***TOpRet***			***BRet***		
	3M	6M	12M	3M	6M	12M	3M	6M	12M	3M	6M	12M	3M	6M	12M	3M	6M	12M	3M	6M	12M
Mean	0.404	1.068	3.401	0.180	0.584	2.761	-1	-2.222	-5.847	-1	-2.222	-5.847	-0.084	0.012	1.378	-0.454	-0.830	-0.954	0.345	0.558	0.968
Max	4.360	6.307	9.150	4.064	6.026	8.503	3.14	2.310	0.873	3.14	2.310	0.873	4.359	6.306	9.117	4.034	6.026	6.381	2.940	2.953	2.58
Min	-3.80	-3.091	-3.479	-1.36	-2.049	-3.244	-5.064	-7.760	-11	-5.064	-7.760	-11	-5.048	-6.265	-11	-5.064	-6.916	-11	-0.910	-1.146	-0.585
Std	1.630	1.940	2.416	1.370	1.844	2.491	1.652	2.048	2.502	1.652	2.048	2.502	1.755	2.472	4.413	1.65	2.419	4.669	0.665	0.791	0.699
Sharpe	0.248	0.550	1.407	0.132	0.317	1.108	-0.605	-1.084	-2.336	-0.605	-1.084	-2.336	-0.048	0.004	0.312	-0.274	-0.343	-0.196	0.519	0.704	1.384
Sks	0.281	0.148	-0.118	0.863	0.451	-0.134	-0.279	-0.209	0.382	-0.279	-0.209	0.382	-0.029	-0.152	-1.129	-0.194	0.082	-0.527	0.702	0.387	0.025
Krs	2.374	2.216	2.940	2.561	2.187	2.70	2.418	2.232	2.841	2.418	2.232	2.841	2.878	2.753	3.601	3.049	2.771	1.972	3.962	2.749	2.512
K-S	0.061 (0)	0.063 (0)	0.030 (0.088)	0.146 (0)	0.094 (0)	0.035 (0.01)	0.055 (0)	0.059 (0)	0.053 (0)	0.055	0.059 (0)	0.053 (0)	0.027 (0.04)	0.037 (0)	0.174 (0)	0.077 (0)	0.060 (0)	0.145 (0)	0.047 (0)	0.044 (0)	0.036 (0.01)

Notes: Mean, Max, Min, and std (standard deviation) are in percentage. Sks is the skewness, Krs is the kurtosis, K-S is the kolmogorov smirnov statistic. Numbers in parenthesis beneath the K-S statistics are the p values.

Table 2. Descriptive Statistics for TND/USD Hedging Strategies

	FRet			***OpRet***			***NhgRet***			***RWRet***			***TFRet***			***TOpRet***			***BRet***		
	3M	6M	12M	3M	6M	12M	3M	6M	12M	3M	6M	12M	3M	6M	12M	3M	6M	12M	3M	6M	12M
Mean	0.117	-0.669	-5.230	1.630	-0.265	-2.951	-0.678	-0.504	2.141	0.596	1.115	2.141	0.966	0.478	-0.226	1.323	0.459	1.640	0.345	0 .558	0.968
Max	11.048	13.024	12.189	10.659	10.921	10.340	9.430	0.095	13.586	11.048	13.024	13.586	11.048	13.024	13.068	10.659	10.913	13.586	2.940	2.953	2.58
Min	-10.43	-11.78	-16.768	-0.709	-3.418	-6.063	-10.99	-0.127	-14.23	-8.949	-11.4	-14.23	-9.237	-11.4	-16.768	-10.02	-11.4	-14.23	-0.910	-1.15	-0.585
Std	4.337	5.710	6.950	2.639	3.691	3.601	4.116	0.051	6.385	4.142	0.053	6.385	4.078	0.053	7.321	3.539	4.783	5.910	0.665	0.791	0.699
Sharpe	0.027	-0.117	-0.752	0.617	-0.072	-0.819	-0.164	-0.098	0.335	0.144	0.219	0.335	0.237	0.089	-0.030	0.374	0.096	0.277	0.519	0.704	1.384
Sks	0.103	0.288	0.515	1.107	1.130	1.917	-0.031	-0.293	-0.406	2.679	-0.272	-0.406	-0.058	-0.089	-0.550	-0.087	-0.211	-0.312	0.702	0.387	0.025
Krs	2.224	2.072	2.526	3.271	2.893	5.86	2.2354	2.062	2.542	2.271	2.379	2.542	2.266	2.163	2.385	2.866	2.269	2.847	3.962	2.749	2.512
K-S	0.055 (0)	0.065 (0)	0.078 (0)	0.208 (0)	0.250 (0)	0.327 (0)	0.054 (0)	0.061 (0)	0.054 (0)	0.052 (0)	0.062 (0)	0.054 (0)	0.047 (0)	0.055 (0)	0.098 (0)	0.085 (0)	0.076 (0)	0.049 (0)	0.047 (0)	0.044 (0)	0.036 (0.012)

Notes: Mean, Max, Min, and std (standard deviation) are in percentage. Sks is the skewness, Krs is the kurtosis, K-S is the kolmogorov smirnov statistic. Numbers in parenthesis beneath the K-S statistics are the p values.

Table 3: Studentized Bootstrap P-Values for the Difference of the Sharpe Ratios in the Case of the TND/EUR Hedging

	Three Months Hedging Horizon		
	BRet-FRet	FRet-OptRet	
Sharpe Ratio Differences	0.270	0.116	
P-Values	0.561	0.018	
	Six Months Hedging Horizon		
	BRet-FRet	Fret-OptRet	OptRet-TFRet
Sharpe Ratio Differences	0.154	0.233	0.312
P-Values	0.775	0.002	0.243
	Twelve Months Hedging Horizon		
	FRet-BRet	BRet-OptRet	OptRet-TFRet
Sharpe Ratio Differences	0.022	0.276	0.796
P-Values	0.988	0.873	0.135

The bootstraps are based on the recentred block bootstrap method with a fixed block size of $\alpha\left[\sqrt{T}\right]$ and 10000 bootstrap replications where $\left[\sqrt{T}\right]$ denotes the largest integer that is less than or equal to $\sqrt{T}$. The p-values are computed based on α=2. Similar results are obtained using $\alpha=4$ (Lim et al. 2006).

Table 4: Studentized Bootstrap P-Values for the Difference of the Sharpe Ratios in the Case of the TND/USD Hedging

	Three Months Hedging Horizon				
	OpRet-Bret	BRet-TOptRet	TOptRet-TFRet	TFRet-RwRet	RwRet-FRet
Sharpe Ratio Differences	0.098	0.145	0.136	0.093	0.117
P-Values	0.473	0.744	0.079	0.566	0.744
	Six Months Hedging Horizon				
	BRet-RwRet	RwRet-TOptRet	TOptRet-TFRet		
Sharpe Ratio Differences	0.485	0.123	0.006		
P-Values	0.237	0.238	0.951		
	Twelve Months Hedging Horizon				
	BRet-NhgRet	NhgRet-TOptRet			
Sharpe Ratio Differences	1.049	0.057			
P-Values	0.509	0.754			

The bootstraps are based on the recentred block bootstrap method with a fixed block size of $\alpha\left[\sqrt{T}\right]$ and 10000 bootstrap replications where $\left[\sqrt{T}\right]$ denotes the largest integer that is less than or equal to $\sqrt{T}$. The p-values are computed based on α=2. Similar results are obtained using $\alpha=4$ (Lim et al. 2006).

Table 5: Bootstrapped P-Values of the Barret and Donald SD Test In the Case of the TND/EUR Hedging

Three Months Headging Horizon

	SDj	FRet	OptRet	NhgRet	ApFRet	ApOptRet	BRet
	SD1		0	0	0	0	0
FRet	SD2		0	0	0	0	0.16
	SD3		0.03	0	0	0	0.77
	SD1	0		0	0	0	0
OptRet	SD2	0.01		0	0	0	0.86
	SD3	0.22		0	0	0	0.83
	SD1	1	1		1	1	0.953
NhgRet	SD2	0.92	0.92		0.92	0.92	0.92
	SD3	0.88	0.88		0.88	0.88	0.88
	SD1	1	0.031	0		0	0
ApFRet	SD2	0.83	0.83	0		0	0.83
	SD3	0.77	0.77	0		0	0.77
	SD1	1	1	0	1		0
ApOptRet	SD2	0.87	0.87	0	0.87		0.87
	SD3	0.85	0.85	0	0.85		0.85
	SD1	0	0	0	0	0	
BRet	SD2	0	0	0	0	0	
	SD3	0	0	0	0	0	

Six Months Headging Horizon

	SDj	FRet	OptRet	NhgRet	ApFRet	ApOptRet	BRet
	SD1		0	0	0	0	0
FRet	SD2		0	0	0	0	0
	SD3		0	0	0	0	0
	SD1	0.025		0	0	0	0
OptRet	SD2	0.36		0	0	0	0.37
	SD3	0.5		0	0	0	0.81
	SD1	1	1		1	1	1
NhgRet	SD2	0.87	0.87		0.87	0.87	0.87
	SD3	0.8	0.8		0.8	0.8	0.8
	SD1	1	0.518	0		0	0
ApFRet	SD2	0.87	0.87	0		0	0.87
	SD3	0.79	0.79	0		0	0.79
	SD1	1	1	0	1		0
ApOptRet	SD2	0.81	0.81	0	0.81		0.81
	SD3	0.76	0.76	0	0.76		0.76
	SD1	0	0	0	0	0	
BRet	SD2	0	0	0	0	0	
	SD3	0	0	0	0	0	

Twelve Months Headging Horizon

	SDj	FRet	OptRet	NhgRet	ApFRet	ApOptRet	BRet
	SD1		0	0	0	0	0
FRet	SD2		0	0	0	0	0
	SD3		0	0	0	0	0
	SD1	0.989		0	0	0	0
OptRet	SD2	0.77		0	0	0	0
	SD3	0.69		0	0	0	0
	SD1	1	1		1	1	1
NhgRet	SD2	0.84	0.84		0.84	0.84	0.84
	SD3	0.79	0.79		0.79	0.79	0.79
	SD1	1	0.518	0		0	0
ApFRet	SD2	0.87	0.87	0		0	0.87
	SD3	0.79	0.79	0		0	0.79
	SD1	1	1	0	1		0
ApOptRet	SD2	0.81	0.81	0	0.81		0.81
	SD3	0.78	0.78	0	0.78		0.78
	SD1	0.023	0	0	0	0	
BRet	SD2	0	0	0	0	0	
	SD3	0	0	0	0	0	

The table read column versus line and contain p-values for testing whether the distrubution of the column hedging strategy stochastically dominates the distribution of the line hedging strategy. P-values for testing the opposite hypothesis read line versus column. The random walk hedging strategy is eliminated when it has the same payoffs as the unhedged strategy

Table 6: Bootstrapped P-Values of the Barret and Donald SD Test In the Case of the TND/USD Hedging

Three Months Headging Horizon

	SDj	FRet	OptRet	NhgRet	RwRet	ApFRet	ApOptRet	BRet
	SD1		0.695	0	0.805	0.999	0.784	0
FRet	SD2		0.87	0	0.87	0.87	0.87	0.87
	SD3		0.8	0	0.8	0.8	0.8	0.8
	SD1	0			0	0	0	0
OptRet	SD2	0		0	0	0	0	0.86
	SD3	0		0	0	0	0	0.83
	SD1	1	1		1	1	1	1
NhgRet	SD2	0.87	0.87		0.87	0.87	0.87	0.87
	SD3	0.79	0.79		0.79	0.79	0.79	0.79
	SD1	0	0.014	0		0.997	0.88	0
RwRet	SD2	0	0.87	0		0.86	0.82	0.06
	SD3	0	0.83	0		0.8	0.76	0.83
	SD1	0	0	0	0		0.486	0
ApFRet	SD2	0	0.83	0	0		0.82	0
	SD3	0	0.79	0	0		0.78	0.79
	SD1	0	0	0	0	0		0
ApOptRet	SD2	0	0.83	0	0	0		0
	SD3	0	0.78	0	0	0		0
	SD1	0	0	0	0	0	0	
BRet	SD2	0	0	0	0	0	0	
	SD3	0	0.03	0	0	0	0	

Six Months Headging Horizon

	SDj	FRet	OptRet	NhgRet	RwRet	ApFRet	ApOptRet	BRet
FRet	SD1		0	0	0.279	0.337	0.002	0
	SD2		0.87	0.43	0.43	0.87	0.87	0.87
	SD3		0.82	0.51	0.51	0.82	0.82	0.82
OptRet	SD1	0		0	0	0	0	0
	SD2	0		0	0	0	0	0.89
	SD3	0		0	0.01	0	0.01	0.88
NhgRet	SD1	0	0		1	1	1	0
	SD2	0.01	0.84		0.84	0.84	0.84	0.84
	SD3	0.02	0.77		0.77	0.77	0.77	0.77
RwRet	SD1	0	0	0		0	0	0
	SD2	0	0	0		0	0	0.01
	SD3	0	0	0		0	0.02	0.87
ApFRet	SD1	0	0	0	0.934		0.059	0
	SD2	0	0	0	0.9		0.68	0.9
	SD3	0	0.24	0	0.83		0.83	0.83
ApOptRet	SD1	0	0	0	0.919	0		0
	SD2	0	0	0	0.7	0.1		0.93
	SD3	0	0.1	0	0.65	0.11		0.87
BRet	SD1	0	0	0	0	0	0	
	SD2	0	0	0	0	0	0	
	SD3	0	0	0	0	0	0	

Twelve Months Headging Horizon

	SDj	FRet	OptRet	NhgRet	ApFRet	ApOptRet	BRet
FRet	SD1		0.018	1	1	1	0
	SD2		0.86	0.86	0.86	0.86	0.86
	SD3		0.82	0.82	0.82	0.82	0.82
OptRet	SD1	0		0	0	0	0
	SD2	0		0	0	0	0.86
	SD3	0		0.19	0	0.21	0.83
NhgRet	SD1	0	0		0	0	0
	SD2	0	0		0	0.03	0
	SD3	0	0		0	0.22	0.81
ApFRet	SD1	0	0	1		0.995	0
	SD2	0	0	0.82		0.82	0.82
	SD3	0	0	0.79		0.79	0.79
ApOptRet	SD1	0	0	0.05	0		0
	SD2	0	0	0.36	0		0.01
	SD3	0	0	0.49	0		0.81
BRet	SD1	0	0	0	0	0	
	SD2	0	0	0	0	0	
	SD3	0	0	0	0	0	

The tables read column versus line and contains p-values for testing whether the distribution of the column hedging strategy stochastically dominates the distribution of the line hedging strategy. P-values for testing the opposite hypothesis read line versus column. The random walk hedging strategy is eliminated when it has the same payoffs as the unhedged strategy.