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Comparative Effectiveness of Financial and Operational Hedging: A Gulf Co-operation Council Perspective

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Abstract

This paper examines the effectiveness of financial-hedging techniques—such as forward hedging—versus operational-hedging techniques, such as risk-sharing arrangements, currency collars and hybrid arrangements for a domestic firm in the Gulf Co-operation Council (GCC) with foreign-currency exposure to the GBP, CHF, and JPY. Our results show that forward hedging is more effective than either risk-sharing arrangements or hybrid arrangements. However, when compared with currency collars, the results are mixed. Moreover, we find that hybrid-arrangements hedging consisting of a 0.667 weight of risk-sharing arrangements represents the optimum weightat which the maximum value of the domestic-currency value of payables, the variance of domestic-currency value of payables, the variance ratio, and variance reduction become insensitive to changes in risk parameters.

Keywords: Financial Hedging, Operational Hedging, Gulf Co-operation Council
JEL Classification: B17

1. Introduction

After the collapse of the Bretton Woods system and the introduction of flexible exchange rates in the early 1970s—coupled with the tendency of firms to engage in international business—the need has arisen to pay attention to fluctuations in exchange rates. Exchange-rate volatility affects not only firms that operate in international markets, but also domestic firms that compete with other firms that import goods from abroad, as well as purely domestic firms such as utility providers. In other words, even domestic firms that operate in the local market are affected by currency fluctuations (Adler and Dumas, 1984; Aggarwal and Harper, 2010).

This paper is concerned with the management of foreign-exchange risk from the perspective of a domestic firm operating in a member country of the Gulf Co-operation Council (GCC). This is a bloc of countries in the Middle East that includes Kuwait, Kingdom of Saudi Arabia (KSA), United Arab Emirates (UAE), Bahrain, Qatar, and The Sultanate of Oman. Apart from Kuwait, which pegs its currency to a basket of currencies, all of these countries adopt a fixed exchange-rate regime in which they peg their currencies to the US dollar. While a policy of pegging to the dollar keeps the exchange rate against the dollar stable, the exchange rates against other currencies remain volatile. Since these countries trade more with the European Union, Japan, and China than with the United States, exposure to foreign-exchange risk is a major issue of concern for businesses using one of the GCC currencies as a base currency. Given that these countries also lack sophisticated financial markets, hedging exposure to foreign-exchange risk becomes a rather challenging task.

The purpose of this paper is to examine the effectiveness of financial-hedging techniques—such as forward hedging—versus operational-hedging techniques, such as risk-sharing arrangements, currency collars and hybrid arrangements for a domestic firm in the GCC with foreign-currency exposure to the GBP, CHF, and JPY. Our results show that forward hedging is more effective than either risk-sharing arrangements or hybrid arrangements. However, when compared with currency collars, the results are mixed. Moreover, we find that hybrid-arrangements hedging consisting of a 0.667 weight of risk-sharing arrangements represents the optimum weightat which the maximum value of the domestic-currency value of payables, the variance of domestic-currency value of payables, the variance ratio, and variance reduction become insensitive to changes in risk parameters. The results from this paper may be beneficial for the managers of firms engaged in international trade, as well as researchers interested in foreign-exchangeriskmanagement. In addition, the results will add value to those agents who employ hedging techniques using the currencies of developing countries that lack sophisticated financial markets. The organisation of this paper is as follows. We start with a literature review in Section 2 and proceed with the methodology in Section 3. Thedata and empirical results are in Section 4, and the conclusion is in Section 5.

2. Literature Review

Foreign-exchange-rate exposure can be classified into three kinds: economic (operating) exposure; transaction exposure; and translation exposure. In their study of the *British Times 1000 Corporations*, Belk and Edelshain (1997) show that the three exposures are linked to each other. They argue that economic exposure in the future will be converted into transaction exposure, and that the choice of the currency by a firm for its future cash flows will consequently affect its revenues and expenses reported in the income statement (translation exposure). Therefore, anything that affects economic exposure will definitely affect the other two exposures. Marshall (2000) points out that these exposures are interrelated and not separate, as a firm might be affected by more than one type.

Transaction exposure pertains to changes in exchange rates after signing an agreement with another party. Khoury and Chan (1988) define it as a 'flow concept'. It is similar to economic exposure in the sense that both arise from future unexpected changes in cash flows. However, they differ in the sense that under transaction exposure, there is a contractual agreement between the two parties, whereas such an agreement is not available under economic exposure. An example of transaction exposure is accounts receivable (cash inflows) and accounts payable (cash outflows). In addition, it is related to trade and capital flows, and this is why it is sometimes known as cash-flow exposure. To sum up, this exposure arises when (i) the firm wants to convert foreign-currency receivables or payables items that have already been incurred on its balance sheet into the domestic currency; and (ii) the firm engages in an agreement that involves future cash flows in a foreign currency being converted into the domestic currency.

Due to the exchange-rate volatility to which firms are exposed, coupled with the objective of minimising unexpected exchange-rate fluctuations, firms have two techniques to hedge their position. These techniques are financial hedging or operational hedging.Financial-hedging techniques involve the use of financial derivatives (such as forwards, futures, swaps, and options), cross-currency hedging (buying a third currency in the spot market or buying a derivative instrument of a third currency), and money-market hedging. These financial-hedging techniques are also known as external hedging techniques (Joseph, 2000). According to Zhou and Wang (2013), the use of financial derivatives minimises the foreign-exchange exposure originating from global business activities.

On the other hand, operational-hedging techniques include leading and lagging, currency diversification, exposure netting, price variation and currency of invoicing, risk-sharing arrangements, and currency collars (Moosa, 2010). Allayannis*et al.* (2001) argue that operational-hedging techniques can maximise shareholders' value if they are employed in conjunction with financial-hedging techniques. In other words, Allayannis suggests that operational hedging cannot be used in the absence of financial hedging.

Operational-hedging techniques, which are also known as internal-hedging techniques, are employed when financial-hedging techniques (such as derivatives) are unavailable or are not easy to acquire. Pramborg (2005) also finds that internal-hedging techniques are widely used among Swedish and Korean firms. For example, he finds that matching inflows and outflows is the most popular method in the two countries, followed by the inter-company netting method in Sweden and the leading and lagging method in Korea. Pramborg defines internal hedging as 'leading and lagging of revenues and costs, netting of trade receivables and payables among associated companies, and domestic currency invoicing'. On the other hand, Bodnar*et al.* (1998) find that a large number of firms use foreign-currency derivatives to manage short-term maturity exposure, while few firms do so when they have long-term maturity exposure. Logue (1995) and Chowdhry and Howe (1999) share the point of view that operational hedging should be used to manage long-term exposure, whereas financial hedging should be used to manage short-term exposure. It is notable that Bodnar*et al.* (1998) find that nearly 44 per cent of firms that use derivatives in hedging currency exposure do not have a benchmark against which to evaluate their performance and to decide whether their risk-management process is useful or not.

Naylor and Greenwood (2006) find that 55 per cent of firms in New Zealand use internal-hedging techniques; however, although this percentage is very high for a small open economy, it is still lower than the international norm. Moreover, they find that matching, and leading and lagging are the most commonly used techniques by those firms. El-Masry (2003) conducts a survey covering UK non-financial firms and finds that 67 per cent of firms use derivatives to hedge four types of financial risk—interest-rate risk, foreign-exchange risk, commodity-price risk, and equity-price risk. Of those firms that manage risk by derivatives, 64 per cent of them use currency derivatives to manage foreign-exchange risk.

The literature contains many studies covering the use of financial instruments to hedge exposure to foreign-exchange risk, whereas studies of operational hedging are few and limited, despite the importance of minimising foreign-exchange risk. For example, Hommel (2003) argues that operational hedging can be used as a strategic complementary tool, as well as financial hedging, as it improves the minimisation of the variance. He further states that operational flexibility can also add value to the firm, as it reduces the effective cost of production and puts a limit on the downside-performance risk. On the other hand, Huston and Laing (2014) find that financial hedging and operational hedging can be used as complements only in the absence of stressed situations, whereas during tough periods (such as the global financial crisis) operational hedging can be used as a substitute for financial hedging. This is because of its effectiveness in dealing with highly volatile exchange rates. This argument is supported by Dong *et al.* (2014), who find that operational hedging can minimise downside risk with a highly volatile exchange rate, as well as increasing the firm's expected profit. Bradley and Moles (2002) find that operational hedging is extensively used by publicly listed UK non-financial firms. Davies *et al.* (2006) find that internal-hedging instruments are used more by Norwegian exporting firms than external-hedging instruments. Pantzalis*et al.* (2001) find that MNCs with a greater breadth (the number of countries across which MNCs' subsidiaries are scattered) face lower foreign-exchange risk, whereas MNCs with greater depth (MNCs' subsidiaries concentrated in a small number of countries) will experience higher foreign-exchange risk.

Joseph (2000) shows that firms in the United Kingdom pay greater attention to the use of currency derivatives (external-hedging techniques) than to internal-hedging techniques, whereas Marshall (2000) shows that a large number of firms in the United States, the United Kingdom, and Asia use both internal and external methods; only a few of them do not use hedging instruments. In addition, in exploring the use of internal and external methods with respect to each type of exposure, Marshall finds that with respect to transaction exposure, the majority of firms use netting followed by matching as the most popular internal-hedging methods; forward contracts followed by options are the widely used instruments of the external-hedging method. McDonald and Moosa (2003) find that both risk-sharing arrangements and currency collars are as effective as forward contracts, especially when the exchange rates of RS and CC become very close to the upper and lower values (very wide neutral zone). Moosa and McDonald (2005) show that operational-hedging techniques (such as risk-sharing arrangements and currency collars) are as effective as financial-hedging techniques (such as forward contracts). Using a Nash-equilibrium simulation model for the CAD and GBP, Moosa and Lien (2004) find that if one of the firms is more risk-averse than the other, both parties will benefit from hedging. In addition, they find that at a certain level of risk aversion, the risk-sharing-threshold parameter has a positive relationship with the standard deviation of the exchange rate.

In his study on the USD and CAD, Moosa (2006) finds that the hybrid operational technique with a weight of 0.664 allocated to risk-sharing arrangements can totally eliminate the sensitivity of cash flows to the value of the parameters. In addition, Moosa (2011) finds that allocating weights of two-thirds to risk-sharing arrangements and one-third to currency collars can effectively eliminate the sensitivity of cash flows to the value of the risk parameters.

3. Methodology

To examine the effectiveness of operational hedging against that of financial hedging equations of risk-sharing arrangements and currency collars; we testthe effectiveness of forward hedging, risk-sharing arrangements, currency collars, and hybrid-arrangement techniques. We assume different values of the changing risk parameter θ in this example such as 0.001, 0.002, 0.004, 0.006, 0.008, and 0.01.[1] $\bar{S}$ represents the sample mean of the spot rates for the covered period.

Financial Hedging

Firms can either buy foreign-currency forward or futures contracts to hedge payables, or sell foreign-currency forward or futures contracts to hedge receivables. A forward contract is an agreement between two parties to buy and sell an asset based on the future price at a specific time in the future. One of the parties goes long on the contract (buying the asset), while the other party goes short (selling

[1] It is a parameter that determines the strike price. The choice of the values of this parameter is arbitrary. A problem usually arises concerning the value of θ as it determines how much of risk to be shifted to the exporter or the importer. In other words, the value determines the risk distribution between the 2 parties and could generate a problem between them if they have different risk tolerance (as both of them try to select the value that makes him insensitive to change in the exchange rate).

the asset). The pay-off for the party with a long position is $S_{t+1} - F_t$, whereas the pay-off for the party with a short position is $F_t - S_{t+1}$. F_t stands for the forward price on which both parties have agreed, whereas S_{t+1} stands for the future spot price at the maturity of the contract. The contract is traded overthecounter where there is no clearing house or physical exchange to regulate the procedure. Forward contracts are not standardised and are initiated between a bank and a customer, based on their needs.

A futures contract can be used in a similar manner to a forward contract, except that a futures contract is astandardised contract with respect to the settlement date and size. It also requires an initial margin and needs to be marked to market on a daily basis. If the market value of the contract falls below the maintenance margin (which is usually below the initial margin), a margin call is needed to satisfy the requirement. In addition, a clearing house exists for futures contracts that operates as an intermediary that guarantees the performance of the two parties to the trade. These differences make forward contracts more attractive than futures contracts. Clark and Ghosh (2004) recognise four disadvantages of futures contracts: (i) short maturity; (ii) the fixed maturity of the contract size; (iii) infrequent maturity date of the contract; and (iv) margin requirements. Therefore, if the holder of a futures contract expects the interest rate to be constant during the life of the contract, the value of the futures contract will decline relative to a forward contract (Khoury and Chan, 1988). In addition, Khoury and Chan show that futures contracts are ranked as the third preferred method after forward contracts and the matching method because of cost, liquidity, and expected profit. Lien and Tse (2001) find that hedging effectiveness improves when the hedger uses futures instead of options to hedge currency risk. Moreover, Albuquerque (2007) finds that using futures instead of options improves hedging results when the downside risk becomes the firm's main consideration. This situation is opposed only when the hedger becomes optimistic and less worried about large losses.

Forward Hedging of Payables

Suppose that an importing firm has a short exposure (payables) of K in foreign currency y to be paid at time $t + 1$ in the future (settlement date). If the firm does not buy foreign currency forward F and the spot rate S rises, the firm will incur a loss on the due date. However, if the spot rate falls, the firm will make profit. On the other hand, if the firm is hedged by buying foreign currency forward atF_t (KF_t amount of x) and the spot rateS_{t+1} rises ($KF_t < KS_{t+1}$), risk will be reduced because the firm will be locked in the exchange rate $\pi = K(S_{t+1} - F_t)$. However, if the spot rateS_{t+1}falls, the firm will make a loss.

In terms of the comparison between forward hedging and money-market hedging, if covered interest rate parity (CIP) holds, then implicit forward rate $\bar{F}_t$ created by money-market hedging will equal forward rate $\bar{F}_t = F_t$, which means that both forward hedging and money-market hedging are effective and produce the same result.[2] However, if $KF_t < K\bar{F}_t$, then forward hedging is better than money-market hedging. Finally, if $KF_t < K\bar{F}_t < KS_{t+1}$, this means that forward hedging is better than both money-market hedging and the no-hedging decision.

Risk-Sharing Arrangements

With this technique, the importer and exporter face the burden of foreign-exchange risk when they both use domestic-currency terms in the invoice for part of the shipment (Moosa, 2010). The parties may agree to add a clause that allows them to set and change the base price due to a change in the exchange rate. This clause is named a price-adjustment clause (Shapiro, 2010). The parties agree on a base rate$\bar{S}$, which is a sample mean of the spot rates for the covered period, and a range of exchange rates called

[2] Under money-market hedging, the hedger borrows in domestic currency and lends in foreign currency, or vice versa, to cover expected receivables or payables. This process creates implicit forward rate $\bar{F}_t$and suggests that forward contract can be replicated when the covered interest rate parity (CIP) do hold. Therefore, the investor locks his future pay-off by a forward contract.

the neutral zone with minimum and maximum values of $\bar{S}(1-\theta)$ and $\bar{S}(1+\theta)$, respectively, where θ is between 0 and 1. Suppose that an importing firm adopts x as its base currency and has k payables in foreign-currency y. If the spot rate on the settlement date S_{t+1} is within the neutral zone$\bar{S}(1-\theta) < S_{t+1} < \bar{S}(1+\theta)$, then the cash flow (payables) in the domestic-currency will be calculated by using the base rate $\bar{S}$, which gives$V_x = K\bar{S}$. This suggests that in the neutral zone, the sensitivity of the domestic-currency value to the spot rate on the settlement date is zero,$dV_x/dS_{t+1} = 0$. However, when the spot rate moves outside the neutral zone, payables are calculated as follows. If the spot rate on the settlement date depreciates and falls below the minimum value $S_{t+1} < \bar{S}(1-\theta)$, the domestic currency value of the cash flow will be calculated as

$$V_x = K\left[\bar{S} - \frac{\bar{S}(1-\theta)-S_{t+1}}{2}\right] > KS_{t+1} \quad (1)$$

In this case, the payee will benefit because the amount that they will receive is not fully affected by depreciation of the foreign currency compared with the no-hedge decision, whereas the payer will suffer because they will not enjoy full depreciation of the currency.

On the other hand, if the spot rate on the settlement date rises beyond the maximum value $S_{t+1} > \bar{S}(1+\theta)$, the domestic currency cash flow will be calculated as

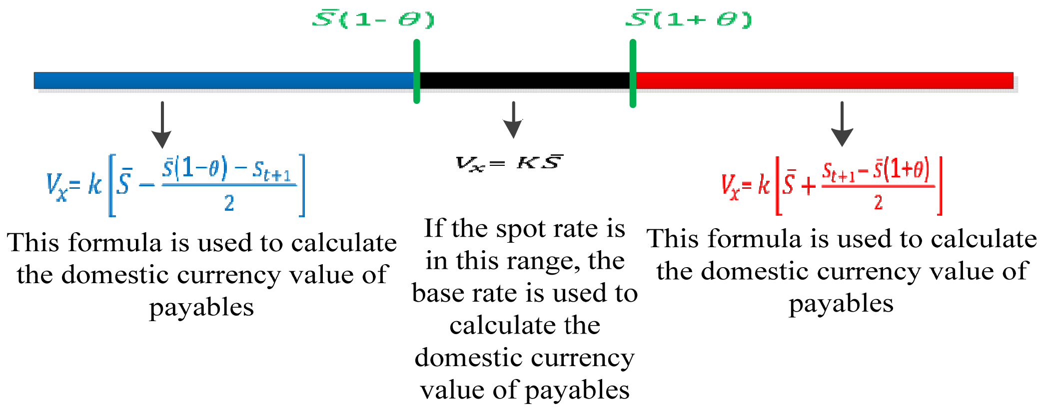
$$V_x = K\left[\bar{S} + \frac{S_{t+1}-\bar{S}(1+\theta)}{2}\right] < KS_{t+1} \quad (2)$$

In this case, the payer will benefit because the amount that they will pay is not fully affected by appreciation of the foreign currency compared with the no-hedge decision, whereas the payee will suffer because they will not enjoy full appreciation of the currency. As a result, under the no-hedge decision$dV_x = KdS_{t+1}$, as$dV_x/dS_{t+1} = K$, whereas under a risk-sharing arrangement, the risk is shared between the two parties, $dV_x = KdS_{t+1}/2$, which gives$dV_x/dS_{t+1} = K/2$.

In sum, if the spotrate, on the settlement date$S_{t+1}$is within the neutral zone $\bar{S}(1-\theta) < S_{t+1} < \bar{S}(1+\theta)$, the base rate itself will be used to calculate the domestic-currency value of payables $V_x = K\bar{S}$. If the spotrate exceeds the maximum value $S_{t+1} > \bar{S}(1+\theta)$, the domestic-currency value of payables will be calculated by dividing the difference between the current rate and the maximum value by 2 and then adding the outcome to the base rate and multiplying by k amount using this formula, which gives $V_x = K\left[\bar{S} + \frac{S_{t+1}-\bar{S}(1+\theta)}{2}\right]$.

On the other hand, if the spot rate on the settlement date rate falls below the minimum value $S_{t+1} < \bar{S}(1-\theta)$, the domestic-currency value of payables will be calculated by dividing the difference between the spot rate and the minimum value by 2 and then subtracting the outcome from the base rate and multiplying by K amount, which gives$V_x = K\left[\bar{S} - \frac{\bar{S}(1-\theta)-S_{t+1}}{2}\right]$. It should be noted that as θ increases, the possibility that cash flows will be converted at a fixed exchange rate $\bar{S}$increases, because the neutral zonebecomes wider. Therefore, an importer with a highly risk-averse profile will ask for the highestθ to ensure that the cash flows (payables) are converted at a fixed exchange rate, whereas an exporter does not need to engage in hedging at all, as they are not exposed to currency risk and they sell goods (receivables) in the currency y. If the exporter decides to participate in a risk-sharing arrangement due to influence from the importer, they will ask for the lowest θ to avoid converting cash flows (receivables) at a fixed exchange rate. Figure 3 shows an example of a risk-sharing arrangement for an importer with payables in a foreign currency.

Figure 3: Conversion Rates under Risk-Sharing Arrangement

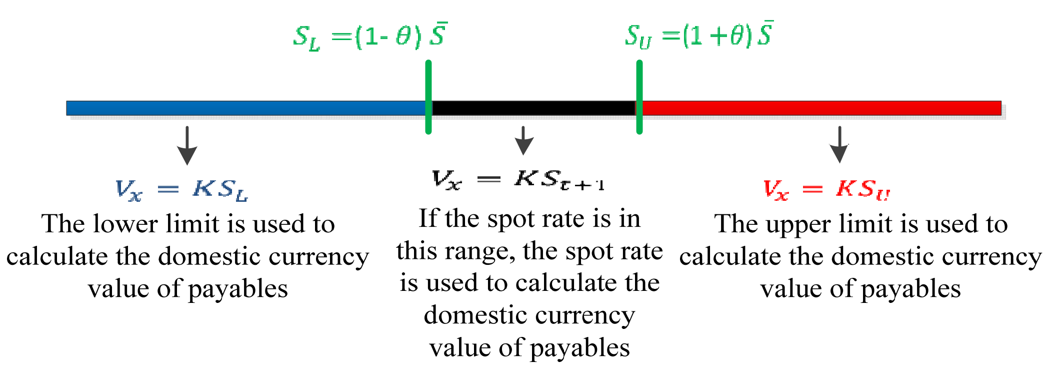


Currency Collars

The currency-collars technique, which is also known as range forward (Moosa, 2003), involves the determination of a minimum value S_L and a maximum value S_U. If the spot rate on the settlement date S_{t+1} exceeds the maximum value, the two parties use the maximum value, whereas if the spot rate S_{t+1} falls below the minimum value, the two parties use the minimum value. If the spot rate $S_{t+1}$is in the range between the minimum and the maximum values, the spot rate S_{t+1}itself is used by the two parties. Moosa (2003) argues that the currency collar works as a trade-off between prospective gain and prospective loss. It can be created by taking a strategy of short-call and long-put with an exercise exchange rate of S_U and S_L, respectively. The pay-off from such a strategy is called the cylinder (Moosa, 2003; Shapiro, 2010). This means that we set a maximum value (cap) for the payables of an importing company at the expense of setting a minimum value (floor)—that is, scarifying the prospective profit from foreign-currency depreciation (Moosa, 2003). The opposite applies to an exporting company, in which we set a minimum value (floor) at the expense of setting a maximum value (cap)—that is, scarifying the prospective loss from foreign currency appreciation.

An importing firm that wants to hedge its payables in a foreign currency engages in a currency-collars agreement with the exporter in which they agree on risk parameter θ, a base rate$\bar{S}$, a lower rate $S_L$and an upper rate S_U. Figure 4 shows how the currency collars work in the case of payables in a foreign currency.

Figure 4: Conversion Rates under Currency Collars



On the settlement date, if the spot rate S_{t+1} is within the maximum-minimum range$S_L < S_{t+1} < S_U$, the spot rate itself will be used to calculate the domestic-currency value of payables, $V_x = KS_{t+1}$, which means that the sensitivity of the domestic-currency value of cash flows to the spot rate on the settlement date$dV_x = KdS_{t+1}$, which gives$dV_x/dS_{t+1} = K$. If the spot rate on the settlement date exceeds the maximum rate $S_{t+1} > S_U$, the domestic-currency value of payables will be calculated using the maximum rate itself as $V_x = KS_U$. On the other hand, if the spot rate on the settlement date falls below the minimum value $S_{t+1} < S_L$, the domestic-currency value of payables will be calculated using the minimum rate itself as $V_x = KS_L$. Therefore, at both $S_{t+1} > S_U$and$S_{t+1} < S_L$,the sensitivity of the domestic-currency value of payables to the spot rate on the settlement date equal to zero, that is, $dV_x/dS_{t+1} = 0$.

It should be noted that, as θincreases, the neutral range widens. Therefore, in contrast to the risk-sharing arrangement (RS), an importer with a highly risk-averse profile under a currency collar will ask for the lowest value ofθ so that the possibility of converting their cash flows (payables) at the spot rate on the settlement date is minimised. In addition, when $S_{t+1}<\bar{S}(1-\theta)$ and $S_{t+1}>\bar{S}(1+\theta)$, the exporter is subject to foreign-exchange risk and they will ask for the highest value of θ to ensure converting their cash flow (receivables) at the spot rateprevailing on the settlement date, given that the currency of invoicing is y. To sum up, as long as the currency of invoicing is y, and there is no agreement that obliges the exporter to participate in operational hedging, the importer is the only party that is exposed to foreign-exchange risk with $dV_x/dS_{t+1} = K$, whereas the exporter is not exposed to such risk, given that $dV_y/dS_{t+1} = 0$and, as a result, theywill remain unhedged.

Sometimes, some pressure maybe put by the importer on the exporter to enter into operational hedging. If such pressure exists and the exporter enters into operational hedging (such as a risk-sharing arrangement or currency collars) their main concern will be associated with the amount of risk that will be shifted from the importer to the exporter, which will urge them, the exporter, to ask for the lowest value of risk parameterθ.

Hybrid Arrangement

A hybrid arrangement is a hedging technique based on the weighted average of the two exchange rates under a risk-sharing arrangement and currency collars that is used to convert cash flows. According to Moosa (2011), an exporter would prefer a hybrid arrangement to both a risk-sharing arrangement and currency collars due to the sensitivity of V_x to changesin θ. The following equationsare used to calculate the domestic-currency value of payables under the hybrid arrangement, where βrepresents the weight assigned to each technique:

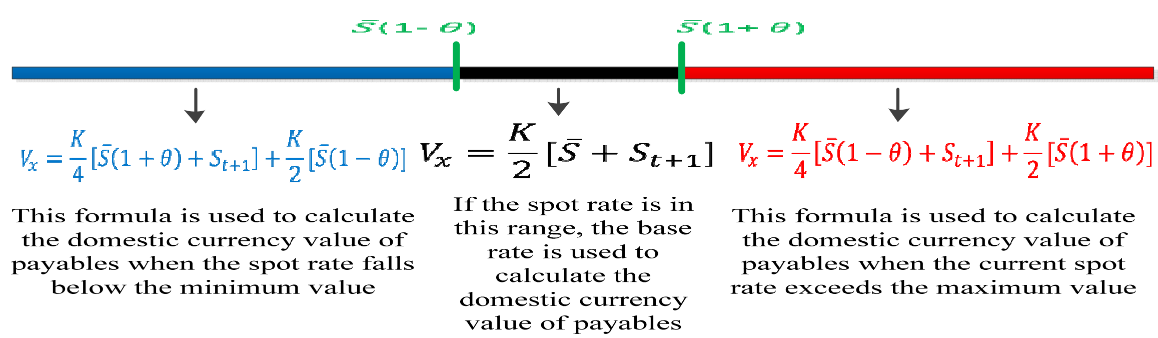
$$V_x = \frac{\beta K}{2}[\bar{S}(1+\theta)+S_{t+1}] + (1-\beta)K\bar{S}(1-\theta) \text{If } S_{t+1}<\bar{S}(1-\theta) \quad (3)$$

$$V_x = \beta K\bar{S} + (1-\beta)KS_{t+1} \text{If } \bar{S}(1-\theta)<S_{t+1}<\bar{S}(1+\theta) \quad (4)$$

$$V_x = \frac{\beta K}{2}[\bar{S}(1-\theta)+S_{t+1}] + (1-\beta)K\bar{S}(1+\theta) \text{If } S_{t+1}>\bar{S}(1+\theta) \quad (5)$$

Figure 5 shows how the hybrid arrangement is structured where the cash flows are calculated from the perspective of an importer with payables in a foreign currency, and equal weights of the risk-sharing arrangement and the currency collars ($\beta = 0.5$).

Figure 5: Hybrid Arrangement for Equal Weights ($\boldsymbol{\beta = 0.5}$)



In a real-life scenario, in which we have different risk preferences for both the importer and exporter, they will negotiate the value of θ. Hence, they may not reach an agreement regarding the exact value of θ. In this case, they either do not engage in operational hedging or they modify the weights of the risk-sharing arrangement and currency collars to produce a value of the cash flow that is insensitive to changes in the risk parameter that is, $dV_x/d\theta = 0$. This means that the hybrid arrangement solves the problem associated with different preferences for risk tolerance between the two parties to the trade.

Moosa (2009) argues that when both the importer and exporter decide to enter into operational hedging, the importer would prefer to use either of the two hedging techniques, which are the risk-sharing arrangement and the currency collars, as they are better than being unhedged; the exporter would prefer to enter into a hybrid arrangement, as it is better for them than the risk-sharing arrangement and the currency collars. The reason for such preferences lies behind the sensitivity of V_x to changes in θ. For example, for an importer with payables in foreign currency y, when $S_{t+1}<\bar{S}(1-\theta)$, $dV_x/d\theta = K\bar{S}/2$ for the risk-sharing arrangement and $dV_x/d\theta = -K\bar{S}$ for the currency collars. This means that a change in θ has a positive effect on V_x for the risk-sharing arrangement, $dV_x/d\theta > 0$, and a negative effect for the currency collars, $dV_x/d\theta < 0$. When $S_{t+1}>\bar{S}(1+\theta)$, the opposite is true. For example, for the risk-sharing arrangement $dV_x/d\theta = -K\bar{S}/2$, which means that $dV_x/d\theta < 0$, and for the currency collars $dV_x/d\theta = K\bar{S}$, which means that $dV_x/d\theta > 0$. These relationships suggest that a change in θ has different effects in the opposite direction on V_x for each of the risk-sharing arrangement and the currency collars. As a result, a hybrid arrangement that combines the risk-sharing arrangement and the currency collars with optimum weights will absolutely eliminate the effect of θ on V_x. Table 1 summarises the relationship between θ and V_x for each type of operational hedging from the perspective of an importer with payables in foreign currency y. It shows that the negative relationship between V_x and θ under hybrid hedging is the same as the relationship under the currency collars when $S_{t+1}<\bar{S}(1-\theta)$. On the other hand, the positive relationship between V_x and θ under hybrid hedging is the same as the relationship under the risk-sharing arrangement when $S_{t+1}>\bar{S}(1+\theta)$. In addition, the table shows that the hybrid arrangement of equal weights can minimise the sensitivity of $dV_x/d\theta$ from $\frac{1}{2}K\bar{S}$ under the risk-sharing arrangement to $\frac{1}{4}K\bar{S}$ underhybrid arrangement,as well as minimising $dV_x/d\theta$ from $K\bar{S}$ under the currency collars to $\frac{1}{4}K\bar{S}$ under hybrid arrangement.

Table 1: Relationship betweenthe Domestic-Currency Value of Payables $\boldsymbol{V_x}$ and $\boldsymbol{\theta}$

Price condition	RS	CC	HY (β =0.5)
$S_{t+1}<\bar{S}(1-\theta)$	$\frac{dV_x}{d\theta}=\frac{K\bar{S}}{2}>0$	$\frac{dV_x}{d\theta}=-K\bar{S}<0$	$\frac{dV_x}{d\theta}=-\frac{K\bar{S}}{4}<0$
$\bar{S}(1-\theta)<S_{t+1}<\bar{S}(1+\theta)$	$\frac{dV_x}{d\theta}=0$	$\frac{dV_x}{d\theta}=0$	$\frac{dV_x}{d\theta}=0$
$S_{t+1}>\bar{S}(1+\theta)$	$\frac{dV_x}{d\theta}=-\frac{K\bar{S}}{2}<0$	$\frac{dV_x}{d\theta}=K\bar{S}>0$	$\frac{dV_x}{d\theta}=\frac{K\bar{S}}{4}>0$

Source: Moosa (2011)

Given that Equation(3) is used to calculate the cash flow under the hybrid arrangement when $S_{t+1}<\bar{S}(1-\theta)$, we demonstrate how to construct a hybrid arrangement of different weight combinations that provides us with a domestic cash flow V_x that is insensitive to a change in θ. If $S_{t+1}<\bar{S}(1-\theta)$, then

$$V_x = \frac{\beta K}{2}[\bar{S}(1+\theta)+S_{t+1}] + (1-\beta)K\bar{S}(1-\theta) \tag{6}$$

which can be manipulated to obtain

$$V_x = \frac{\beta K\bar{S}}{2} + \frac{\beta K\bar{S}\theta}{2} + \frac{\beta K S_{t+1}}{2} + (1-\beta)(K\bar{S} - K\bar{S}\theta) \quad (7)$$

by differentiating Equation (7) with respect to θ, we obtain

$$\frac{dV_x}{d\theta} = \frac{\beta K\bar{S}}{2} - (1-\beta)K\bar{S} \quad (8)$$

by equating the first derivative to zero (as V_x insensitive to θ), we obtain

$$\frac{\beta K\bar{S}}{2} - (1-\beta)K\bar{S} = 0 \quad (9)$$

Equation (9) can be solved for β, which gives $\beta = 2/3$. By substituting this value into Equation (6) and simplifying, we end up with the expression

$$V_x = \frac{K}{3}(2\bar{S} + S_{t+1}) \quad (10)$$

The result means that the weight of the risk-sharing arrangement in the hybrid arrangement is equal to $\beta = 0.667$, whereas the weight of the currency collars equals $1 - \beta = 0.333$.

In addition, we test the variability of the domestic-currency cash flows under no hedge against the variability of the domestic-currency value of payables under operational hedging (such as risk-sharing arrangements, currency collars, and hybrid arrangements) using the following hypotheses:

$$H1_0: \sigma^2(V_U) = \sigma^2(V_{RS}) \quad (11)$$

$$H2_0: \sigma^2(V_U) = \sigma^2(V_{CC}) \quad (12)$$

$$H3_0: \sigma^2(V_U) = \sigma^2(V_{HY}) \quad (13)$$

where $\sigma^2(V_U)$isthe variance of the domestic-currency value of payables under the no hedge, whereas $\sigma^2(V_{RS})$, $\sigma^2(V_{CC})$, and $\sigma^2(V_{HY})$are the variance of the domestic-currency value of payables under risk-sharing arrangements, currency collars, and hybrid arrangements, respectively.

We also test the variability of thedomestic-currency value of payables under no hedge against the variability of the domestic-currency value of payables underfinancial hedging (forward contract) using the following hypothesis:

$$H4_0: \sigma^2(V_U) = \sigma^2(V_F) \quad (14)$$

where $\sigma^2(V_F)$isthe variance of the domestic-currency value of payables under the forward hedge.
We alsotest the variability of thedomestic-currency value of payables under forward contracts against the variability of the domestic-currency value of payables underrisk-sharing arrangements, currency collars, and hybrid arrangements(equal weights) given different sets of parameters values θusing the following hypotheses:

$$H5_0: \sigma^2(V_{RS}) = \sigma^2(V_F) \quad (15)$$

$$H6_0: \sigma^2(V_{CC}) = \sigma^2(V_F) \quad (16)$$

$$H7_0: \sigma^2(V_{HY}) = \sigma^2(V_F) \quad (17)$$

Similarly to McDonald and Moosa (2003), we investigate which hedging tool is more effective in minimising the variability of domestic-currency cash flows under the hedge and the no-hedge decision using the variance ratio as in

$$VR = \frac{\sigma^2(V_U)}{\sigma^2(V_H)} \geq F_\alpha(n-1, n-1) \quad (18)$$

where $\sigma^2(V_U)$ is the domestic currency value of payables under the unhedged positionand $\sigma^2(V_H)$ is the domestic currency value of payables under the hedged position. $n$is the corresponding sample size. And accompanied with variance reduction

$$VD = 100\left[1 - \frac{\sigma^2(V_H)}{\sigma^2(V_U)}\right] = 100\left[1 - \frac{1}{VR}\right] \quad (19)$$

In addition, we determine whether the hybrid arrangement—based on the weighted average of the two exchange rates under risk-sharing arrangements—and currency collars—that are used to convert foreign payables into the domestic-currency value—can reduce the sensitivity of the cash flows to the value of the parameters. We also find the optimum weight of risk-sharing arrangement β in which the domestic-currency value of payables under the hybrid arrangement becomes insensitive to the change in risk parameter θ, as in Equations (3), (4), and (5). This will be accomplished bystudying the effect of the risk parameter on the maximum value of the payables in the domestic currency V_x (Max), the variance of the payables in the domestic currency$Var.(V_x)$, thevariance ratio (VR), and the variance reduction (VD).

4. Data and Empirical Results

We use a sample of end-of-the-month data for the spot exchange rate and the one-month forward rate of the Kuwaiti dinar (KWD), Saudi riyal (SAR), Emirati dirham (AED), Bahraini dinar (BHD) and Qatari riyal (QAR) as base currencies against the US dollar (USD), British pound (GBP), Swiss franc (CHF), and Japanese yen (JPY). The data are obtained from Thomson Reuters' *DataStream* and the International Monetary Fund's *International Financial Statistics* CD-ROM for the period 1:2000 to 11:2011. We assign x to the base currency and y to the exposure currency and assume a domestic firm in the GCC with payables of 100 in the foreign currency (exposure currency y). Table 2 summarises the sample data period for each currency, depending on availability.[3]

Table 2: Sample Data Period for Each Currency against the CHF, GBP, and JPY

Base Currency (x)	Period (End of the Month)	Number of Observations
KWD	1:2000 - 11:2011	143
SAR	1:2000 - 11:2011	143
AED	5:2000 - 11:2011	139
QAR	7:2004 - 11:2011	89
BHD	3:2004 - 11:2011	93

Tables 3 to 7 show the empirical results of the VR and VD for all of the seven hypotheses that test the effectiveness of financial hedging versus operational hedging. Regarding RS, when compared with the unhedged decision, the results show that the VR is significant at the 5% level of significance for all of the currency combinations. This result is valid for all of the given risk parameters, which range from 0.001 to 0.01. Tables 8 to 12 showV_x *(Max)*,$Var.(V_x)$, the VR and the VD of RS, CC, and HY (equal weights β=0.50) for all of the currency combinations under different risk parameters θ. The tables show that as θ increases, V_x *(Max)* under RS decreases.In addition, as θ increases,$Var.(V_x)$decreases under RS. The results also show that for RS, the effectiveness of the hedge represented by the VD is positively related to the value of the risk parameter—that is, as θ increases, the VD increases consequently (see Tables 8 to 12 and Figures 7to 9). This suggests that we have a wider range for converting cash flows at the fixed rate $\bar{S}$ (the neutral zone).

Tables 3 to 7 also show the results of CC when compared with the unhedged decision. They show that the VR for all of the currency combinations is significant. This result is valid for all of the given risk parameters. However, the relationship under CC between the VD and the value of risk parameter θ is negative.That is, as θ increases, the VD decreases (see Tables 8 to 12 and Figures 10 to

[3] We encountered several limitations related to data availability. This problem is normal for researchers working with data for developing countries. For example Oman is excluded from this study because of inaccurate exchange-rate data and the unavailability of interest rates. In addition, the sample period for each country in this study is not exactly the same because of a lack of interest-rate data for most of the countries at the time of collecting the data.

12). This suggests that a higher θ means a greater range for the cash flow to be converted at the current spot rate, S_{t+1} (the neutral zone).The tables show that as θ increases, V_x *(Max)* increases under CC. In addition, as θ increases,$Var.(V_x)$ increases under CC.

Tables 3 to 7 also show the results of HY when compared with the unhedged decision. They show that the VR for all of the currency combinations is significant. This result is valid for all of the given risk parameters. The relationship under HY (equal weights) between the VD and the value of risk parameter θ is negative. That is, as θ increases, the VD decreases (see Tables 8 to 12 and Figures 13 to 15). This relationship suggests that a higher θ means a greater range for the cash flow to be converted at $\bar{S} + S_{t+1}/2$ (the neutral zone).The tables show that as θincreases, V_x *(Max)* increases under HY. In addition, as θ increases,$Var.(V_x)$ increases under HY.

In examining the ranges of V_x *(Max)*,$Var.(V_x)$, VR, and VD for risk parameter θ (Tables 8 to 12), we notice that under HY, the ranges of $Var.(V_x)$, VR, and VD have a middle value between RS and CC, while the range of V_x *(Max)*has the lowest value compared with RS and CC. This means that the value of payables $V_x$under HY has the lowest sensitivity to the changes in risk parameter θ compared with RS and CC.

Table 3: Results of Hypothesis Testing of KWD

	$H_0:\sigma^2(V_U)=\sigma^2(V_{RS})$		$H_0:\sigma^2(V_U)=\sigma^2(V_{CC})$		$H_0:\sigma^2(V_U)=\sigma^2(V_{HY})$		$H_0:\sigma^2(V_U)=\sigma^2(V_F)$		$H_0:\sigma^2(V_{RS})=\sigma^2(V_F)$		$H_0:\sigma^2(V_{CC})=\sigma^2(V_F)$		$H_0:\sigma^2(V_{HY})=\sigma^2(V_F)$	
	VR	**VD(%)**	**VR**	**VD(%)**	**VR**	**VD(%)**	**VR**	**VD(%)**	**VR**	**VD(%)**	**VR**	**VD(%)**	**VR**	**VD(%)**
θ= 0.001														
KWD/GBP	4.037*	75.233	9621.168*	99.990	15.569*	93.577	3614.064*	99.972	895.080*	99.888	[2.662]*	62.436	232.119*	99.569
KWD/JPY	3.889*	74.291	15430.155*	99.994	15.153*	93.400	52.799*	98.106	13.573*	92.632	[292.238]*	99.657	3.484*	71.300
KWD/CHF	3.982*	74.888	26552.287*	99.996	15.632*	93.603	180.764*	99.447	45.392*	97.797	[146.888]*	99.319	343.154*	99.708
θ= 0.002														
KWD/GBP	4.113*	75.687	2416.239*	99.959	15.290*	93.459	3614.064*	99.972	878.663*	99.886	1.495*	33.143	236.364*	99.576
KWD/JPY	3.941*	74.631	3870.041*	99.974	14.955*	93.313	52.799*	98.106	13.394*	92.534	[73.296]*	98.635	3.53*	71.674
KWD/CHF	4.019*	75.123	6713.739*	99.985	15.487*	93.543	180.764*	99.447	44.968*	97.776	[37.140]*	97.307	346.378*	99.711
θ= 0.004														
KWD/GBP	4.269*	76.580	607.836*	99.835	14.751*	93.221	3614.064*	99.972	846.387*	99.881	5.945*	83.181	244.989*	99.591
KWD/JPY	4.048*	75.300	976.077*	99.898	14.570*	93.136	52.799*	98.106	13.041*	92.332	[18.486]*	94.59	3.623*	72.404
KWD/CHF	4.096*	75.587	1719.957*	99.942	15.201*	93.421	180.764*	99.447	44.129*	97.733	[9.514]*	89.49	352.891*	99.716
θ= 0.006														
KWD/GBP	4.435*	77.453	273.011*	99.634	14.240*	92.977	3614.064*	99.972	814.846*	99.877	13.237*	92.445	253.786*	99.605
KWD/JPY	4.159*	75.956	439.154*	99.772	14.198*	92.957	52.799*	98.106	12.694*	92.122	[8.317]*	87.976	3.718*	73.108
KWD/CHF	4.174*	76.044	777.042*	99.871	14.922*	93.298	180.764*	99.447	43.303*	97.69	[4.298]*	76.736	359.491*	99.721
θ= 0.008														
KWD/GBP	4.609*	78.306	154.138*	99.351	13.753*	92.729	3614.064*	99.972	784.034*	99.872	23.446*	95.735	262.765*	99.619
KWD/JPY	4.273*	76.600	248.713*	99.598	13.839*	92.774	52.799*	98.106	12.354*	91.906	[4.710]*	78.770	3.815*	73.788
KWD/CHF	4.254*	76.494	443.646*	99.775	14.650*	93.174	180.764*	99.447	42.490*	97.646	[2.454]*	59.254	366.174*	99.726
θ= 0.01														
KWD/GBP	4.793*	79.138	98.814*	98.988	13.290*	92.475	3614.064*	99.972	753.951*	99.867	36.574*	97.265	271.926*	99.632
KWD/JPY	4.392*	77.232	160.199*	99.376	13.492*	92.588	52.799*	98.106	12.021*	91.681	[3.034]*	67.041	3.913*	74.445
KWD/CHF	4.336*	76.937	287.322*	99.652	14.384*	93.048	180.764*	99.447	41.689*	97.601	[1.589]*	37.086	372.939*	99.731

* Significant at the 5% level, [ ]* Variance ratio is inverted and significant at the 5% level, [ ] Variance ratio is inverted but insignificant at the 5% level

Before discussing the effectiveness of operational hedging versus financial hedging (forward contract), we discuss the effectiveness of financial hedging versus the no-hedge decision (Tables 3 to 7). The results show that the VR of financial hedging (forward contract) is significant for all of the currency combinations under all of the given risk parameters θ. The VD shows that forward contracts are highly effective in minimising the variance of the unhedged payables by more than 99 per cent. This means that forward hedging is better than RS and HY in minimising the variance of unhedged payables (hypotheses 1, 3, and 4). However, when compared with CC (hypotheses 2 and 4), the results are mixed.

When we compare the effectiveness of financial hedging versus operational hedging (hypotheses 5,6,and 7), the results (Tables 3 to 7) show that financial hedging yields much better results than RS for all of the currency combinations under different risk parameters (hypothesis 5). Further, the results show that financial hedging is more effective than HY in minimising risk for all of the currency combinations under different risk parameters (hypothesis 7). However, in relation to financial hedging versus CC, the results are mixed (hypothesis 6).

Tables 13 to 17 agree with the theoretical foundation on the behaviour of HY before and after the optimum weight of 0.667, which makes V_x *(Max)*, $Var.(V_x)$, VR, and VD insensitive to a changes in θ. For example the tables show that when the weight of RS is below β<0.667, HY behaviour follows CC behaviour in which as θ increases, V_x *(Max)* and $Var.(V_x)$ increase, whereas VR and VD decrease. However, when the weight of RS exceeds β>0.667, HY behaviour follows RS behaviour in which as θ increases, V_x *(Max)* and $Var.(V_x)$ decrease, whereas VR and VD increase. It is also notable that when the weight of RS is equal to 0.667, as θincreases there are no changes in V_x *(Max)*, $Var.(V_x)$, VR, and VD.

5. Conclusion

In this paper, we examined the effectiveness of financial-hedging techniques-such as forward hedging-versus operational-hedging techniques-such as risk-sharing arrangements, currency collars, and hybrid arrangements-for a domestic firm in the GCC with foreign-currency exposure to the GBP, CHF, and JPY. We found that forward hedging is more effective than either risk-sharing arrangements or hybrid arrangements. However, when compared with currency collars, the results are mixed. We also found that a hybrid-arrangement hedging with a 0.667 weight of risk-sharing arrangements represents the optimum weight at which the maximum value of the domestic-currency value of payables, the variance of domestic-currency value of payables, the variance ratio, and variance reduction become insensitive to changes in risk parameters.

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Table 4: Results of Hypothesis Testing of SAR

	$H_0\!:\sigma^2(V_U)=\sigma^2(V_{RS})$		$H_0\!:\sigma^2(V_U)=\sigma^2(V_{CC})$		$H_0\!:\sigma^2(V_U)=\sigma^2(V_{HY})$		$H_0\!:\sigma^2(V_U)=\sigma^2(V_F)$		$H_0\!:\sigma^2(V_{RS})=\sigma^2(V_F)$		$H_0\!:\sigma^2(V_{CC})=\sigma^2(V_F)$		$H_0\!:\sigma^2(V_{HY})=\sigma^2(V_F)$	
	VR	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**
θ= 0.001														
SAR/GBP	4.056*	75.346	13054.808*	99.992	15.728*	93.642	9058.496*	99.988	2233.239*	99.955	[1.441]*	30.611	575.920*	99.826
SAR/JPY	3.875*	74.196	22228.429*	99.995	15.166*	93.406	422.897*	99.763	109.121*	99.083	[52.562]*	98.097	27.884*	96.413
SAR/CHF	3.987*	74.924	37824.741*	99.997	15.699*	93.63	29238.143*	99.996	7331.753*	99.986	[1.293]	22.701	1862.360*	99.946
θ= 0.002														
SAR/GBP	4.120*	75.729	3263.702*	99.969	15.488*	93.543	9058.496*	99.988	2198.538*	99.954	2.775*	63.97	584.855*	99.829
SAR/JPY	3.918*	74.478	5632.421*	99.982	15.001*	93.334	422.897*	99.763	107.927*	99.073	[13.318]*	92.491	28.189*	96.452
SAR/CHF	4.019*	75.123	9492.641*	99.989	15.575*	93.579	29238.143*	99.996	7273.497*	99.986	3.080*	67.533	1877.212*	99.946
θ= 0.004														
SAR/GBP	4.252*	76.484	815.925*	99.877	15.022*	93.343	9058.496*	99.988	2130.177*	99.953	11.102*	90.992	602.986*	99.834
SAR/JPY	4.005*	75.036	1433.636*	99.93	14.680*	93.188	422.897*	99.763	105.568*	99.052	[3.390]*	70.501	28.806*	96.528
SAR/CHF	4.084*	75.517	2378.617*	99.957	15.330*	93.477	29238.143*	99.996	7158.143*	99.986	12.292*	91.864	1907.202*	99.947
θ= 0.006														
SAR/GBP	4.390*	77.223	362.633*	99.724	14.576*	93.139	9058.496*	99.988	2063.204*	99.951	24.979*	95.996	621.464*	99.839
SAR/JPY	4.095*	75.585	646.055*	99.845	14.368*	93.04	422.897*	99.763	103.247*	99.031	[1.527]*	34.541	29.431*	96.602
SAR/CHF	4.150*	75.907	1069.009*	99.906	15.090*	93.373	29238.143*	99.996	7044.294*	99.985	27.350*	96.343	1937.547*	99.948
θ= 0.008														
SAR/GBP	4.534*	77.947	203.981*	99.509	14.147*	92.931	9058.496*	99.988	1997.618*	99.949	44.408*	97.748	640.289*	99.843
SAR/JPY	4.188*	76.125	367.321*	99.727	14.066*	92.89	422.897*	99.763	100.964*	99.009	1.151*	13.141	30.064*	96.673
SAR/CHF	4.217*	76.291	606.292*	99.835	14.854*	93.268	29238.143*	99.996	6931.914*	99.985	48.224*	97.926	1968.251*	99.949
θ= 0.01														
SAR/GBP	4.685*	78.656	131.045*	99.236	13.736*	92.72	9058.496*	99.988	1933.411*	99.948	69.124*	98.553	659.431*	99.848
SAR/JPY	4.283*	76.657	237.642*	99.579	13.772*	92.739	422.897*	99.763	98.716*	98.987	1.779*	43.806	30.705*	96.743
SAR/CHF	4.286*	76.671	392.022*	99.744	14.624*	93.162	29238.143*	99.996	6820.959*	99.985	74.582*	98.659	1999.285*	99.949

* Significant at the 5% level, [ ]* Variance ratio is inverted and significant at the 5% level, [ ] Variance ratio is inverted but insignificant at the 5% level

Table 5: Results of Hypothesis Testing of AED

	$H_0\!:\sigma^2(V_U)=\sigma^2(V_{RS})$		$H_0\!:\sigma^2(V_U)=\sigma^2(V_{CC})$		$H_0\!:\sigma^2(V_U)=\sigma^2(V_{HY})$		$H_0\!:\sigma^2(V_U)=\sigma^2(V_F)$		$H_0\!:\sigma^2(V_U)=\sigma^2(V_{HY})$		$H_0\!:\sigma^2(V_{RS})=\sigma^2(V_F)$		$H_0\!:\sigma^2(V_{CC})=\sigma^2(V_F)$	
	VR	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**
θ= 0.001														
AED/GBP	4.081*	75.499	13229.185*	99.992	15.829*	93.682	5434.649*	99.981	1331.523*	99.924	[2.434]*	58.919	343.327*	99.708
AED/JPY	3.875*	74.196	22778.163*	99.995	15.166*	93.406	534.112*	99.812	137.819*	99.274	[42.646]*	97.655	34.817*	97.127
AED/CHF	4.003*	75.018	36553.021*	99.997	15.754*	93.652	21422.239*	99.995	5351.497*	99.981	[1.706]*	41.394	1359.720*	99.926
θ= 0.002														
AED/GBP	4.145*	75.878	3307.296*	99.969	15.588*	93.585	5434.649*	99.981	1310.938*	99.923	1.643*	39.144	348.627*	99.713
AED/JPY	3.918*	74.478	5734.920*	99.982	15.002*	93.334	534.112*	99.812	136.313*	99.266	[10.737]*	90.686	35.197*	97.158
AED/CHF	4.035*	75.22	9210.445*	99.989	15.628*	93.601	21422.239*	99.995	5308.225*	99.981	2.325*	57.005	1370.756*	99.927
θ= 0.004														
AED/GBP	4.277*	76.624	826.824*	99.879	15.122*	93.387	5434.649*	99.981	1270.384*	99.921	6.572*	84.786	359.382*	99.721
AED/JPY	4.005*	75.035	1453.029*	99.931	14.681*	93.188	534.112*	99.812	133.337*	99.25	[2.720]*	63.241	35.967*	97.219
AED/CHF	4.101*	75.62	2330.694*	99.957	15.378*	93.497	21422.239*	99.995	5222.581*	99.98	9.191*	89.12	1393.025*	99.928
θ= 0.006														
AED/GBP	4.416*	77.355	367.477*	99.727	14.674*	93.185	5434.649*	99.981	1230.651*	99.918	14.789*	93.238	370.342*	99.729
AED/JPY	4.095*	75.584	652.802*	99.846	14.370*	93.041	534.112*	99.812	130.408*	99.233	[1.222]	18.181	36.747*	97.278
AED/CHF	4.169*	76.015	1043.761*	99.904	15.133*	93.392	21422.239*	99.995	5138.097*	99.98	20.524*	95.127	1415.562*	99.929
θ= 0.008														
AED/GBP	4.560*	78.071	207.334*	99.517	14.245*	92.98	5434.649*	99.981	1191.735*	99.916	26.211*	96.184	381.499*	99.737
AED/JPY	4.188*	76.123	369.802*	99.729	14.067*	92.891	534.112*	99.812	127.525*	99.215	1.444*	30.763	37.537*	97.335
AED/CHF	4.238*	76.404	592.648*	99.831	14.893*	93.285	21422.239*	99.995	5054.705*	99.98	36.146*	95.127	1438.363*	99.93
θ= 0.01														
AED/GBP	4.7108*	78.772	132.962*	99.247	13.833*	92.77	5434.649*	99.981	1153.633*	99.913	40.873*	97.553	392.857*	99.745
AED/JPY	4.283*	76.655	237.977*	99.579	13.774*	92.74	534.112*	99.812	124.688*	99.198	2.244*	55.444	38.337*	97.391
AED/CHF	4.308*	76.788	382.279*	99.738	14.658*	93.178	21422.239*	99.995	4972.452*	99.9798	56.038*	98.215	1461.413*	99.931

* Significant at the 5% level, [ ]* Variance ratio is inverted and significant at the 5% level, [ ] Variance ratio is inverted but insignificant at the 5% level

Table 6: Results of Hypothesis Testing of QAR

	$H_0: \sigma^2(V_U) = \sigma^2($		$H_0: \sigma^2(V_U) = \sigma^2(V_{CC}$		$H_0: \sigma^2(V_U) = \sigma^2(V$		$H_0: \sigma^2(V_U) = \sigma^2(V_F)$		$H_0: \sigma^2(V_{RS}) = \sigma^2(V_F)$		$H_0: \sigma^2(V_{CC}) = \sigma^2(V_F)$		$H_0: \sigma^2(V_{HY}) = \sigma^2($	
	VR	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**	**VR**	**VD (%)**
θ= 0.001														
QAR/GBP	4.026*	75.166	10829.245*	99.99	15.567*	93.576	4045.159*	99.975	1004.54*	99.9	[2.677]*	62.645	259.841*	99.615
QAR/JPY	3.899*	74.353	20144.054*	99.995	15.223*	93.431	556.204*	99.82	142.647*	99.298	[36.216]*	97.238	36.535*	97.263
QAR/CHF	3.978*	74.864	16605.753*	99.993	15.521*	93.557	9048.386*	99.988	2274.4	99.956	[1.835]*	45.51	582.958*	99.828
θ= 0.002														
QAR/GBP	4.096*	75.59	2707.885*	99.963	15.307*	93.467	4045.159*	99.9752	987.405*	99.898	1.493*	33.058	264.265*	99.621
QAR/JPY	3.946*	74.664	5079.972*	99.98	15.041*	93.351	556.204*	99.8202	140.919*	99.29	[9.133]*	89.051	36.977*	97.295
QAR/CHF	4.028*	75.176	4151.438*	99.975	15.329*	93.476	9048.386*	99.988	2246.09*	99.955	2.179*	54.119	590.24*	99.83
θ= 0.004														
QAR/GBP	4.241*	76.423	676.995*	99.852	14.803*	93.244	4045.159*	99.975	953.699*	99.895	5.975*	83.264	273.251*	99.634
QAR/JPY	4.045*	75.278	1274.857*	99.921	14.686*	93.19	556.204*	99.82	137.503*	99.272	[2.292]*	56.371	37.872*	97.359
QAR/CHF	4.131*	75.793	1037.859*	99.903	14.955*	93.313	9048.386*	99.988	2190.28*	99.954	8.718*	88.529	605.008*	99.834
θ= 0.006														
QAR/GBP	4.393*	77.238	302.619*	99.669	14.323*	93.018	4045.159*	99.975	920.735*	99.891	13.367*	92.518	282.416*	99.645
QAR/JPY	4.146*	75.882	567.077*	99.823	14.342*	93.027	556.204*	99.82	134.142*	99.254	[1.019]	1.917	38.780*	97.421
QAR/CHF	4.236*	76.398	461.270*	99.783	14.593	93.147	9048.386*	99.988	2135.57*	99.953	19.616*	94.902	620.049*	99.838
θ= 0.008														
QAR/GBP	4.552	78.035	172.293*	99.419	13.865*	92.788	4045.159*	99.975	888.51*	99.887	23.478*	95.74	291.736*	99.657
QAR/JPY	4.251*	76.477	319.088*	99.686	14.009*	92.861	556.204*	99.82	130.836*	99.235	1.7431*	42.631	39.702*	97.481
QAR/CHF	4.3461*	76.991	260.878*	99.616	14.241*	92.978	9048.386*	99.988	2081.91*	99.951	34.684*	97.116	635.347*	99.842
θ= 0.01														
QAR/GBP	4.720*	78.813	110.988*	99.099	13.428*	92.553	4045.159*	99.975	857.009*	99.883	36.446*	97.256	301.233*	99.668
QAR/JPY	4.359*	77.0617	204.252*	99.51	13.686*	92.693	556.204*	99.82	127.584*	99.216	2.723*	63.277	40.638*	97.539
QAR/CHF	4.458*	77.572	167.438*	99.402	13.901*	92.806	9048.386*	99.988	2029.33*	99.95	54.039*	98.149	650.913*	99.846

* Significant at the 5% level, [ ]* Variance ratio is inverted and significant at the 5% level, [ ] Variance ratio is inverted but insignificant at the 5% level

Table 7: Results of Hypothesis Testing of BHD

	$H_0: \sigma^2(V_U) = \sigma^2($		$H_0: \sigma^2(V_U) = \sigma^2(V_{C}$		$H_0: \sigma^2(V_U) = \sigma^2$		$H_0: \sigma^2(V_U) = \sigma^2$		$H_0: \sigma^2(V_{RS}) = \sigma$		$H_0: \sigma^2(V_{CC}) = \sigma$		$H_0: \sigma^2(V_{HY}) = \sigma$	
	VR	**VD(%)**	**VR**	**VD(%)**	**VR**	**VD(%)**	**VR**	**VD(%)**	**VR**	**VD(%)**	**VR**	**VD(%)**	**VR**	**VD(%)**
θ = 0.001														
BHD/GBP	4.029*	75.18	10242.521*	99.99	15.567*	93.576	6677.986*	99.985	1657.435*	99.939	[1.533]*	34.801	428.956*	99.766
BHD/JPY	3.864*	74.123	19601.128*	99.994	15.101*	93.377	67.869*	98.526	17.562*	94.306	[288.804]*	99.653	775.766*	99.871
BHD/CHF	3.965*	74.781	16932.289*	99.994	15.471*	93.536	10976.756*	99.99	2768.155*	99.963	[1.542]*	35.172	709.469*	99.859
θ= 0.002														
BHD/GBP	4.100*	75.61	2571.555*	99.961	15.303*	93.4654	6677.986*	99.985	1628.724*	99.938	2.596*	61.492	436.376*	99.77
BHD/JPY	3.912*	74.44	4919.107*	99.979	14.920*	93.2978	67.869*	98.526	17.346*	94.235	[72.478]*	98.62	785.148*	99.872
BHD/CHF	4.015*	75.094	4233.072*	99.976	15.281*	93.4561	10976.756*	99.99	2733.780*	99.963	2.593*	61.436	718.306*	99.86
θ= 0.004														
BHD/GBP	4.247*	76.455	643.666*	99.844	14.791*	93.239	6677.986*	99.985	1572.275*	99.936	10.354*	90.342	451.461*	99.778
BHD/JPY	4.011*	75.07	1230.507*	99.918	14.568*	93.135	67.869*	98.526	16.919*	94.089	[18.130]*	94.484	804.131*	99.875
BHD/CHF	4.117*	75.712	1058.268*	99.905	14.909*	93.292	10976.756*	99.99	2666.001*	99.962	10.372*	90.359	736.223*	99.864
θ= 0.006														
BHD/GBP	4.401*	77.281	290.204*	99.655	14.305*	93.009	6677.986*	99.98	1517.134*	99.934	23.011*	95.654	466.826*	99.785
BHD/JPY	4.113*	75.689	546.893*	99.817	14.227*	92.971	67.869*	98.526	16.499*	93.939	[8.057]*	87.589	823.407*	99.878
BHD/CHF	4.222*	76.317	470.341*	99.787	14.549*	93.126	10976.756*	99.99	2599.520*	99.961	23.337*	95.715	754.464*	99.867
θ= 0.008														
BHD/GBP	4.563*	78.088	165.321*	99.395	13.841*	92.775	6677.986*	99.985	1463.248*	99.931	40.393*	97.524	482.470*	99.792
BHD/JPY	4.219*	76.298	308.617*	99.675	13.897*	92.804	67.869*	98.526	16.086*	93.783	[4.547]*	78.008	842.976*	99.881
BHD/CHF	4.331*	76.911	264.567*	99.622	14.199*	92.957	10976.756*	99.99	2534.335*	99.9609	41.489*	97.589	773.030*	99.87
θ= 0.01														
BHD/GBP	4.734*	78.876	106.516*	99.061	13.398*	92.536	6677.986*	99.985	1410.609*	99.929	62.694*	98.404	498.417*	99.799
BHD/JPY	4.328*	76.897	198.249*	99.495	13.577*	92.634	67.869*	98.526	15.679*	93.622	[2.921]*	65.765	862.826*	99.884
BHD/CHF	4.443*	77.493	169.6735*	99.41	13.861*	92.785	10976.756*	99.99	2470.466*	99.959	64.693*	98.454	791.897*	99.873

* Significant at the 5% level, [ ]* Variance ratio is inverted and significant at the 5% level, [ ] Variance ratio is inverted but insignificant at the 5% level

Table 8: V_x(Max), $Var.(V_x)$, VR, and VD of KWD

		KWD/GBP			KWD/JPY			KWD/CHF		
	θ	**RS**	**CC**	**HY (β=0.5)**	**RS**	**CC**	**HY (β=0.5)**	**RS**	**CC**	**HY (β=0.5)**
V_x (Max)	0.001	53.372	49.017	51.194	0.317	0.274	0.295	29.081	23.549	26.315
	0.002	53.347	49.066	51.206	0.317	0.274	0.295	29.069	23.572	26.321
	0.004	53.298	49.164	51.231	0.317	0.275	0.296	29.046	23.619	26.333
	0.006	53.249	49.262	51.255	0.316	0.275	0.296	29.022	23.666	26.344
	0.008	53.200	49.36	51.280	0.316	0.276	0.296	28.999	23.713	26.356
	0.01	53.151	49.458	51.304	0.316	0.276	0.296	28.975	23.760	26.368
	range	0.220	0.440	0.110	0.001	0.002	0.0006	0.105	0.211	0.052
$Var.$ (V_x)	0.001	5.611	0.002	1.455	0.000286	7.223E-08	7.35477E-05	3.653	0.0005	0.930
	0.002	5.508	0.009	1.481	0.000282	2.88E-07	7.45201E-05	3.619	0.0021	0.939
	0.004	5.305	0.037	1.535	0.000275	1.142E-06	7.64908E-05	3.551	0.0084	0.957
	0.006	5.108	0.082	1.590	0.000267	2.538E-06	7.84943E-05	3.485	0.0187	0.974
	0.008	4.915	0.146	1.647	0.000260	4.481E-06	8.05315E-05	3.419	0.0327	0.993
	0.01	4.726	0.229	1.704	0.000253	6.957E-06	8.26013E-05	3.355	0.0506	1.011
	range	0.884	0.226	0.249	3.27719E-05	6.885E-06	9.05358E-06	0.298	0.050	0.080
VR	0.001	4.037	9621.17	15.569	3.889	15430	15.153	3.982	26552.287	15.632
	0.002	4.113	2416.24	15.290	3.941	3870	14.955	4.019	6713.739	15.487
	0.004	4.269	607.837	14.751	4.048	976.08	14.570	4.096	1719.957	15.201
	0.006	4.435	273.011	14.240	4.159	439.15	14.198	4.174	777.042	14.922
	0.008	4.609	154.138	13.753	4.273	248.71	13.839	4.254	443.646	14.650
	0.01	4.793	98.814	13.290	4.392	160.2	13.492	4.336	287.322	14.384
	range	0.755	9522.35	2.279	0.502	15270	1.660	0.353	26264.965	1.248
VD	0.001	75.233	99.989	93.577	74.291	99.994	93.400	74.888	99.996	93.603
	0.002	75.687	99.958	93.459	74.631	99.974	93.313	75.123	99.985	93.543
	0.004	76.580	99.835	93.221	75.300	99.898	93.136	75.587	99.941	93.421
	0.006	77.453	99.633	92.977	75.956	99.772	92.957	76.044	99.871	93.298
	0.008	78.306	99.351	92.729	76.600	99.598	92.774	76.494	99.774	93.174
	0.01	79.138	98.988	92.475	77.232	99.376	92.588	76.937	99.651	93.048
	range	3.904	1.001	1.101	2.940	0.617	0.812	2.048	0.344	0.555

Table 9: V_x(Max), $Var.(V_x)$, VR, and VD of SAR

		SAR/GBP			SAR/JPY			SAR/CHF		
	θ	**RS**	**CC**	**HY (β=0.5)**	**RS**	**CC**	**HY (β=0.5)**	**RS**	**CC**	**HY (β=0.5)**
V_x (Max)	0.001	703.921	631.926	667.923	4.215	3.544	3.879	390.035	304.891	347.463
	0.002	703.606	632.557	668.081	4.214	3.547	3.880	389.883	305.195	347.539
	0.004	702.974	633.819	668.397	4.210	3.554	3.882	389.579	305.804	347.691
	0.006	702.343	635.082	668.713	4.207	3.561	3.884	389.274	306.414	347.844
	0.008	701.712	636.345	669.028	4.203	3.568	3.886	388.969	307.023	347.996
	0.01	701.080	637.607	669.344	4.199	3.575	3.887	388.665	307.632	348.148
	range	2.840	5.681	1.420	0.015	0.031	0.007	1.370	2.741	0.685
$Var.$ (V_x)	0.001	1260.757	0.391	325.131	0.065	1.13842E-05	0.0166	879.546	0.092	223.416
	0.002	1241.167	1.566	330.175	0.064	4.4928E-05	0.0168	872.557	0.369	225.197
	0.004	1202.575	6.267	340.411	0.063	0.0001	0.0172	858.719	1.474	228.795
	0.006	1164.765	14.102	350.843	0.061	0.0003	0.0176	845.061	3.281	232.435
	0.008	1127.740	25.070	361.470	0.060	0.0006	0.0179	831.579	5.785	236.119
	0.01	1091.492	39.023	372.276	0.059	0.0010	0.0183	818.269	8.947	239.842
	range	169.265	38.632	47.145	0.006	0.0010	0.0016	61.276	8.854	16.426
VR	0.001	4.056	13054.808	15.728	3.875	22228.429	15.166	3.987	37824.741	15.699
	0.002	4.120	3263.702	15.488	3.918	5632.421	15.001	4.019	9492.641	15.575
	0.004	4.252	815.925	15.022	4.005	1433.636	14.680	4.084	2378.617	15.330
	0.006	4.390	362.633	14.576	4.095	646.055	14.368	4.150	1069.009	15.090
	0.008	4.534	203.981	14.147	4.188	367.321	14.066	4.217	606.292	14.854
	0.01	4.685	131.045	13.736	4.283	237.642	13.772	4.286	392.022	14.624
	range	0.629	12923.763	1.991	0.408	21990.787	1.393	0.298	37432.718	1.0752
VD	0.001	75.346	99.992	93.642	74.196	99.995	93.406	74.924	99.997	93.630
	0.002	75.729	99.969	93.543	74.478	99.982	93.334	75.123	99.989	93.579
	0.004	76.484	99.877	93.343	75.036	99.930	93.188	75.517	99.957	93.477
	0.006	77.223	99.724	93.139	75.585	99.845	93.040	75.907	99.906	93.373
	0.008	77.947	99.509	92.931	76.125	99.727	92.890	76.291	99.835	93.268
	0.01	78.656	99.236	92.720	76.657	99.579	92.739	76.671	99.744	93.162
	range	3.309	0.755	0.921	2.460	0.416	0.667	1.747	0.252	0.468

Table 10: V_x*(Max)*, *Var.*(V_x), VR, and VD of AED

		AED/GBP			AED/JPY			AED/CHF		
	θ	RS	CC	HY (β=0.5)	RS	CC	HY (β=0.5)	RS	CC	HY (β=0.5)
V_x *(Max)*	0.001	690.732	619.907	655.319	4.123	3.472	3.798	383.140	300.896	342.018
	0.002	690.422	620.527	655.474	4.122	3.475	3.799	382.989	301.196	342.093
	0.004	689.803	621.765	655.784	4.1187	3.482	3.800	382.689	301.798	342.243
	0.006	689.183	623.004	656.094	4.115	3.489	3.802	382.388	302.399	342.393
	0.008	688.564	624.242	656.403	4.111	3.496	3.804	382.087	303.000	342.544
	0.01	687.945	625.481	656.713	4.108	3.503	3.805	381.787	303.601	342.694
	range	2.786	5.573	1.393	0.015	0.031	0.007	1.3526	2.705	0.676
Var. (V_x)	0.001	1230.842	0.379	317.367	0.064	1.09469E-05	0.0164	818.528	0.089	207.973
	0.002	1211.813	1.518	322.266	0.063	4.34795E-05	0.0166	811.910	0.355	209.661
	0.004	1174.326	6.075	332.208	0.062	0.0001	0.0169	798.810	1.405	213.067
	0.006	1137.598	13.670	342.339	0.060	0.0003	0.0173	785.888	3.139	216.514
	0.008	1101.624	24.229	352.652	0.059	0.0006	0.0177	773.133	5.528	220.002
	0.01	1066.403	37.782	363.152	0.058	0.0010	0.0181	760.552	8.571	223.527
	range	164.439	37.403	45.785	0.006	0.001	0.001	57.976	8.481	15.554
VR	0.001	4.081	13229.185	15.829	3.875	22778.163	15.166	4.003	36553.021	15.754
	0.002	4.145	3307.296	15.588	3.918	5734.920	15.002	4.035	9210.445	15.628
	0.004	4.277	826.824	15.122	4.005	1453.029	14.681	4.101	2330.694	15.378
	0.006	4.416	367.477	14.674	4.095	652.802	14.370	4.169	1043.761	15.133
	0.008	4.560	207.334	14.245	4.188	369.802	14.067	4.238	592.648	14.893
	0.01	4.710	132.962	13.833	4.283	237.977	13.774	4.308	382.279	14.6585
	range	0.629	13096.222	1.995	0.408	22540.186	1.392	0.305	36170.741	1.096
VD	0.001	75.499	99.992	93.682	74.196	99.995	93.406	75.018	99.997	93.652
	0.002	75.878	99.969	93.585	74.478	99.982	93.334	75.220	99.989	93.601
	0.004	76.624	99.879	93.387	75.035	99.931	93.188	75.620	99.957	93.497
	0.006	77.355	99.727	93.185	75.584	99.846	93.041	76.015	99.904	93.392
	0.008	78.071	99.517	92.980	76.123	99.729	92.891	76.404	99.831	93.285
	0.01	78.772	99.247	92.771	76.655	99.579	92.740	76.788	99.738	93.178
	range	3.273	0.744	0.911	2.458	0.415	0.666	1.769	0.258	0.474

Table 11: V_x*(Max)*, *Var.*(V_x), VR, and VD of QAR

		QAR/GBP			QAR/JPY			QAR/CHF		
	θ	RS	CC	HY (β=0.5)	RS	CC	HY (β=0.5)	RS	CC	HY (β=0.5)
V_x *(Max)*	0.001	697.598	641.133	669.366	4.179	3.627	3.903	395.541	329.766	362.653
	0.002	697.278	641.774	669.526	4.178	3.631	3.904	395.376	330.095	362.736
	0.004	696.638	643.055	669.846	4.174	3.638	3.906	395.047	330.754	362.900
	0.006	695.997	644.336	670.166	4.170	3.645	3.908	394.717	331.413	363.065
	0.008	695.357	645.617	670.487	4.167	3.653	3.910	394.388	332.072	363.230
	0.01	694.716	646.898	670.807	4.163	3.660	3.912	394.058	332.731	363.394
	range	2.882	5.764	1.441	0.016	0.032	0.0081	1.482	2.964	0.741
Var. (V_x)	0.001	1102.172	0.409	285.096	0.067	1.31142E-05	0.0173	452.289	0.108	115.927
	0.002	1083.373	1.639	289.949	0.066	5.20029E-05	0.0175	446.659	0.433	117.376
	0.004	1046.391	6.555	299.809	0.065	0.0002	0.0179	435.562	1.733	120.312
	0.006	1010.223	14.666	309.865	0.063	0.0004	0.0184	424.682	3.900	123.303
	0.008	974.867	25.760	320.091	0.062	0.0008	0.0188	414.011	6.897	126.346
	0.01	940.304	39.988	330.510	0.060	0.0012	0.0193	403.554	10.746	129.441
	range	161.867	39.579	45.415	0.0071	0.0012	0.0019	48.735	10.638	13.513
VR	0.001	4.026	10829.245	15.567	3.899	20144.054	15.223	3.978	16605.753	15.521
	0.002	4.096	2707.885	15.307	3.946	5079.972	15.041	4.028	4151.438	15.329
	0.004	4.241	676.995	14.803	4.045	1274.857	14.686	4.131	1037.859	14.955
	0.006	4.393	302.619	14.323	4.146	567.077	14.342	4.236	461.270	14.593
	0.008	4.552	172.293	13.865	4.251	319.088	14.009	4.346	260.878	14.241
	0.01	4.720	110.988	13.428	4.359	204.252	13.686	4.4588	167.438	13.901
	range	0.693	10718.256	2.139	0.460	19939.802	1.536	0.480	16438.314	1.620
VD	0.001	75.166	99.990	93.576	74.353	99.995	93.431	74.864	99.993	93.557
	0.002	75.590	99.963	93.467	74.664	99.980	93.351	75.176	99.975	93.476
	0.004	76.423	99.852	93.244	75.278	99.921	93.190	75.793	99.903	93.313
	0.006	77.238	99.669	93.018	75.882	99.823	93.027	76.398	99.783	93.147
	0.008	78.035	99.419	92.788	76.477	99.686	92.861	76.991	99.616	92.978
	0.01	78.813	99.099	92.553	77.061	99.510	92.693	77.572	99.402	92.806
	range	3.647	0.891	1.023	2.708	0.484	0.737	2.708	0.591	0.751

Table 12: $V_x(Max)$, $Var.(V_x)$, VR, and VD of BHD

		BHD/GBP			BHD/JPY			BHD/CHF		
	θ	**RS**	**CC**	**HY (β=0.5)**	**RS**	**CC**	**HY (β=0.5)**	**RS**	**CC**	**HY (β=0.5)**
V_x (Max)	0.001	72.248	66.429	69.339	0.4339	0.3756	0.4048	40.860	33.958	37.409
	0.002	72.214	66.496	69.355	0.4337	0.3760	0.4049	40.843	33.992	37.417
	0.004	72.148	66.629	69.388	0.4333	0.3767	0.4050	40.809	34.060	37.434
	0.006	72.082	66.761	69.422	0.4330	0.3775	0.4052	40.775	34.127	37.451
	0.008	72.015	66.894	69.455	0.4326	0.3782	0.4054	40.741	34.195	37.468
	0.01	71.949	67.027	69.488	0.4322	0.3790	0.4056	40.707	34.263	37.485
	range	0.298	0.597	0.149	0.0016	0.0033	0.0008	0.152	0.305	0.076
$Var.$ (V_x)	0.001	11.197	0.0044	2.898	0.00071	1.39093E-07	0.000184	4.853	0.001	1.243
	0.002	11.004	0.017	2.948	0.00071	5.56372E-07	0.000186	4.792	0.004	1.259
	0.004	10.622	0.070	3.050	0.00069	2.22549E-06	0.000191	4.674	0.018	1.290
	0.006	10.250	0.155	3.153	0.00067	5.00735E-06	0.000195	4.557	0.040	1.322
	0.008	9.886	0.272	3.259	0.00066	8.90195E-06	0.000200	4.443	0.072	1.355
	0.01	9.530	0.423	3.367	0.00064	1.3879E-05	0.000205	4.331	0.113	1.388
	range	1.667	0.419	0.469	7.58834E-05	1.37399E-05	2.06883E-05	0.521	0.112	0.144
VR	0.001	4.029	10242.521	15.567	3.867	20014.514	15.101	3.965	16932.289	15.471
	0.002	4.100	2571.555	15.303	3.915	5003.628	14.920	4.015	4233.072	15.281
	0.004	4.247	643.666	14.791	4.012	1250.907	14.568	4.117	1058.268	14.909
	0.006	4.401	290.204	14.305	4.112	555.958	14.227	4.222	470.341	14.549
	0.008	4.563	165.321	13.841	4.216	312.726	13.897	4.331	264.5670	14.199
	0.01	4.734	106.516	13.398	4.323	200.582	13.577	4.4431	169.673	13.861
	range	0.7050	10136.004	2.169	0.4558	19813.932	1.523	0.477	16762.615	1.610
VD	0.001	75.180	99.990	93.576	74.145	99.995	93.377	74.781	99.994	93.536
	0.002	75.610	99.961	93.465	74.457	99.980	93.297	75.094	99.976	93.456
	0.004	76.455	99.844	93.239	75.076	99.920	93.135	75.712	99.905	93.292
	0.006	77.281	99.655	93.009	75.684	99.820	92.971	76.317	99.787	93.126
	0.008	78.088	99.395	92.775	76.282	99.680	92.804	76.911	99.622	92.957
	0.01	78.876	99.061	92.536	76.870	99.501	92.634	77.493	99.410	92.785
	range	3.696	0.929	1.0401	2.725	0.493	0.743	2.711	0.583	0.750

Table 13: Sensitivity of KWD to Changes in θ under HY (different weights)

		KWD/GBP				KWD/JPY				KWD/CHF			
	θ	**V_x (Max)**	**$Var.$ (V_x)**	**VR**	**VD (%)**	**V_x (Max)**	**$Var.$ (V_x)**	**VR**	**VD (%)**	**V_x (Max)**	**$Var.$ (V_x)**	**VR**	**VD (%)**
β=0.10	0.001	49.452	0.076	295.578	99.661	0.278	3.6E-06	308.932	99.676	24.102	0.043	337.134	99.703
	0.002	49.494	0.099	227.658	99.560	0.278	4.4E-06	252.404	99.603	24.122	0.050	289.804	99.654
	0.004	49.577	0.155	145.928	99.314	0.279	6.3E-06	175.894	99.431	24.162	0.066	218.805	99.543
	0.006	49.660	0.223	101.216	99.012	0.279	8.6E-06	128.876	99.224	24.202	0.085	169.876	99.411
	0.008	49.744	0.305	74.127	98.651	0.280	1.1E-05	98.154	98.981	24.242	0.107	135.294	99.260
	0.01	49.827	0.400	56.548	98.231	0.280	1.4E-05	77.151	98.703	24.282	0.132	110.098	99.091
	range	0.374	0.324	239.029	1.430	0.0021	1.1E-05	231.78	0.9724	0.179	0.088	227.036	0.61167
β=0.50	0.001	51.194	1.455	15.569	93.577	0.295	7.4E-05	15.153	93.400	26.315	0.930	15.633	93.603
	0.002	51.206	1.481	15.290	93.459	0.295	7.5E-05	14.955	93.313	26.321	0.939	15.487	93.543
	0.004	51.231	1.535	14.751	93.221	0.296	7.6E-05	14.570	93.136	26.333	0.957	15.201	93.421
	0.006	51.255	1.590	14.240	92.977	0.296	7.8E-05	14.198	92.957	26.344	0.974	14.922	93.298
	0.008	51.280	1.647	13.754	92.729	0.296	8.1E-05	13.839	92.774	26.356	0.993	14.650	93.174
	0.01	51.304	1.704	13.290	92.475	0.296	8.3E-05	13.492	92.588	26.368	1.011	14.384	93.048
	range	0.110	0.249	2.279	1.101	0.0006	9.1E-06	1.660	0.812	0.0529	0.080	1.248	0.555
β=0.666	0.001	51.868	2.535	8.937	88.810	0.302	0.0001	8.654	88.445	27.210	1.635	8.894	88.756
	0.002	51.868	2.535	8.937	88.810	0.302	0.0001	8.654	88.445	27.210	1.635	8.894	88.756
	0.004	51.868	2.535	8.937	88.810	0.302	0.0001	8.654	88.445	27.210	1.635	8.894	88.756
	0.006	51.868	2.535	8.937	88.810	0.302	0.0001	8.654	88.445	27.210	1.635	8.894	88.756
	0.008	51.868	2.535	8.937	88.810	0.302	0.0001	8.654	88.445	27.210	1.635	8.894	88.756
	0.01	51.868	2.535	8.937	88.810	0.302	0.0001	8.654	88.445	27.210	1.635	8.894	88.756
	range	0	0	0	0	0	0	0	0	0	0	0	0
β=0.90	0.001	52.936	4.563	4.964	79.856	0.313	0.00023	4.788	79.114	28.528	2.965	4.906	79.617
	0.002	52.919	4.498	5.036	80.144	0.313	0.00023	4.837	79.329	28.520	2.943	4.942	79.765
	0.004	52.885	4.370	5.184	80.710	0.312	0.00023	4.939	79.753	28.503	2.901	5.014	80.059
	0.006	52.850	4.244	5.338	81.267	0.312	0.00022	5.043	80.171	28.487	2.858	5.088	80.349
	0.008	52.816	4.120	5.498	81.814	0.312	0.00022	5.150	80.583	28.470	2.817	5.164	80.636
	0.01	52.782	3.998	5.666	82.351	0.312	0.00021	5.260	80.989	28.454	2.775	5.241	80.92
	range	0.154	0.565	0.701	2.495	0.0008	2.1E-05	0.472	1.874	0.0741	0.189	0.334	1.302

Table 14: Sensitivity of SAR to Changes in θ under HY (different weights)

		SAR/GBP				SAR/JPY				SAR/CHF			
	θ	V_x (Max)	Var. (V_x)	VR	VD (%)	V_x (Max)	Var. (V_x)	VR	VD (%)	V_x (Max)	Var. (V_x)	VR	VD (%)
β=0.10	0.001	639.126	16.468	310.522	99.678	3.611	0.0007	319.833	99.687	313.406	10.132	346.153	99.711
	0.002	639.662	20.698	247.072	99.595	3.614	0.0009	269.698	99.629	313.664	11.532	304.138	99.671
	0.004	640.735	30.854	165.741	99.396	3.620	0.0012	197.863	99.494	314.182	14.730	238.112	99.58
	0.006	641.809	43.275	118.17	99.153	3.626	0.0016	150.657	99.336	314.7	18.434	190.271	99.474
	0.008	642.882	57.961	88.230	98.866	3.632	0.0021	118.288	99.154	315.218	22.641	154.913	99.354
	0.01	643.955	74.797	68.37	98.537	3.638	0.0026	95.293	98.950	315.736	27.323	128.37	99.221
	range	4.829	58.328	242.152	1.140	0.027	0.0018	224.539	0.736	2.330	17.190	217.783	0.490
β=0.50	0.001	667.924	325.131	15.7287	93.6422	3.879	0.0166	15.166	93.406	347.464	223.416	15.6995	93.6304
	0.002	668.082	330.176	15.4884	93.5436	3.880	0.0168	15.002	93.334	347.54	225.198	15.5753	93.5796
	0.004	668.397	340.412	15.0227	93.3434	3.882	0.0172	14.680	93.188	347.692	228.796	15.3304	93.477
	0.006	668.713	350.843	14.576	93.1394	3.884	0.0176	14.368	93.040	347.844	232.436	15.0903	93.3732
	0.008	669.029	361.471	14.1475	92.9316	3.886	0.0179	14.066	92.890	347.997	236.119	14.8549	93.2682
	0.01	669.344	372.277	13.7368	92.7203	3.887	0.0183	13.772	92.739	348.149	239.842	14.6243	93.1621
	range	1.42041	47.145	1.991	0.921	0.007	0.0016	1.393	0.667	0.685	16.426	1.075	0.468
β=0.666	0.001	679.243	567.993	9.003	88.893	3.987	0.029	8.642	88.428	361.293	393.249	8.919	88.788
	0.002	679.243	567.993	9.003	88.893	3.987	0.029	8.642	88.428	361.293	393.249	8.919	88.788
	0.004	679.243	567.993	9.003	88.893	3.987	0.029	8.642	88.428	361.293	393.249	8.919	88.788
	0.006	679.243	567.993	9.003	88.893	3.987	0.029	8.642	88.428	361.293	393.249	8.919	88.788
	0.008	679.243	567.993	9.003	88.893	3.987	0.029	8.642	88.428	361.293	393.249	8.919	88.788
	0.01	679.243	567.993	9.003	88.893	3.987	0.029	8.642	88.428	361.293	393.249	8.919	88.788
	range	0	0.00	0.00	0	0	0.00	0	0	0	0.00	0	0
β=0.90	0.001	696.722	1024.76	4.990	79.961	4.148	0.053	4.772	79.048	381.521	713.696	4.914	79.652
	0.002	696.501	1012.38	5.051	80.203	4.147	0.052	4.813	79.226	381.415	709.283	4.945	79.778
	0.004	696.059	987.901	5.176	80.682	4.144	0.051	4.897	79.579	381.202	700.526	5.006	80.027
	0.006	695.617	963.807	5.305	81.153	4.142	0.050	4.982	79.928	380.988	691.859	5.069	80.275
	0.008	695.176	940.097	5.439	81.616	4.14	0.049	5.069	80.272	380.775	683.278	5.133	80.519
	0.01	694.734	916.772	5.578	82.072	4.137	0.049	5.158	80.612	380.562	674.781	5.198	80.761
	range	1.988	107.989	0.587	2.111	0.011	0.00396	0.385	1.564	0.959	38.914	0.283	1.109

Table 15: Sensitivity of AED to Changes in θunder HY (different weights)

		AED/GBP				AED/JPY				AED/CHF			
	θ	V_x (Max)	Var. (V_x)	VR	VD (%)	V_x (Max)	Var. (V_x)	VR	VD (%)	V_x (Max)	Var. (V_x)	VR	VD (%)
β=0.10	0.001	626.99	16.058	312.843	99.680	3.537	0.0007	319.99	99.687	309.121	9.452	346.63	99.711
	0.002	627.517	20.164	249.135	99.598	3.540	0.0009	269.973	99.629	309.376	10.781	303.91	99.671
	0.004	628.569	30.023	167.326	99.402	3.546	0.0012	198.239	99.495	309.887	13.811	237.233	99.578
	0.006	629.622	42.077	119.392	99.162	3.552	0.0016	151.009	99.337	310.398	17.334	189.022	99.471
	0.008	630.675	56.270	89.277	98.879	3.558	0.0021	118.533	99.156	310.909	21.330	153.608	99.349
	0.01	656.713	361.486	13.897	92.804	3.564	0.0026	95.370	98.951	311.42	25.797	127.014	99.212
	range	29.7231	345.428	298.946	6.875	0.026	0.001	224.619	0.736	2.299	16.344	219.615	0.498
β=0.50	0.001	655.32	317.367	15.829	93.682	3.798	0.0164	15.166	93.406	342.018	207.974	15.754	93.652
	0.002	655.475	322.267	15.588	93.585	3.799	0.0166	15.002	93.334	342.093	209.662	15.628	93.601
	0.004	655.784	332.208	15.122	93.387	3.800	0.0169	14.681	93.188	342.244	213.068	15.378	93.497
	0.006	656.094	342.34	14.674	93.185	3.802	0.0173	14.370	93.041	342.394	216.515	15.133	93.392
	0.008	656.404	352.653	14.245	92.980	3.804	0.0177	14.067	92.891	342.544	220.002	14.893	93.285
	0.01	656.713	363.152	13.833	92.771	3.806	0.018	13.774	92.74	342.695	223.528	14.658	93.178
	range	1.393	45.785	1.995	0.911	0.007	0.001	1.392	0.666	0.676	15.554	1.096	0.474
β=0.666	0.001	666.457	554.472	9.060	88.962	3.902	0.028	8.642	88.428	355.37	366.018	8.952	88.829
	0.002	666.457	554.472	9.060	88.962	3.902	0.028	8.642	88.428	355.37	366.018	8.952	88.829
	0.004	666.457	554.472	9.060	88.962	3.902	0.028	8.642	88.428	355.37	366.018	8.952	88.829
	0.006	666.457	554.472	9.060	88.962	3.902	0.028	8.642	88.428	355.37	366.018	8.952	88.829
	0.008	666.457	554.472	9.060	88.962	3.902	0.028	8.642	88.428	355.37	366.018	8.952	88.829
	0.01	666.457	554.472	9.060	88.962	3.902	0.028	8.642	88.428	355.37	366.018	8.952	88.829
	range	0	0.00	0.00	0	0	0.00	0	0	0	0.00	0	0
β=0.90	0.001	683.65	1000.43	5.021	80.085	4.058	0.052	4.772	79.048	374.916	664.204	4.933	79.728
	0.002	683.433	988.401	5.082	80.325	4.057	0.051	4.813	79.226	374.811	660.025	4.964	79.856
	0.004	682.999	964.624	5.207	80.798	4.055	0.050	4.896	79.579	374.6	651.736	5.027	80.109
	0.006	682.566	941.219	5.337	81.264	4.052	0.050	4.981	79.927	374.39	643.534	5.091	80.359
	0.008	682.132	918.187	5.471	81.723	4.050	0.049	5.068	80.271	374.179	635.415	5.156	80.607
	0.01	681.699	895.523	5.609	82.174	4.047	0.048	5.157	80.611	373.969	627.382	5.222	80.852
	range	1.950	104.906	0.588	2.088	0.010	0.0039	0.384	1.563	0.946	36.821	0.289	1.123

Table 16: Sensitivity of QAR to Changes in θunder HY (different weights)

		QAR/GBP				QAR/JPY				QAR/CHF			
	θ	V_x (Max)	Var. (V_x)	VR	VD (%)	V_x (Max)	Var. (V_x)	VR	VD (%)	V_x (Max)	Var. (V_x)	VR	VD (%)
β=0.10	0.001	646.78	14.756	300.781	99.667	3.683	0.0008	315.847	99.683	336.344	5.628	319.667	99.687
	0.002	647.325	18.892	234.93	99.574	3.686	0.0010	262.684	99.619	336.624	6.834	263.272	99.620
	0.004	648.414	28.940	153.36	99.347	3.692	0.0014	188.671	99.47	337.184	9.715	185.199	99.46
	0.006	649.502	41.293	107.48	99.069	3.698	0.0018	141.314	99.292	337.744	13.223	136.075	99.265
	0.008	650.591	55.790	79.552	98.743	3.704	0.0024	109.463	99.086	338.304	17.329	103.832	99.036
	0.01	651.68	72.551	61.174	98.365	3.710	0.0030	87.127	98.852	338.864	22.052	81.5968	98.774
	range	9.799	1003.8	296.423	22.616	0.055	0.002	298.087	0.888	5.040	17.472	311.302	0.9710
β=0.50	0.001	669.366	285.09	15.567	93.576	3.903	0.0173	15.223	93.431	362.654	115.928	15.521	93.557
	0.002	669.526	289.95	15.307	93.467	3.904	0.0175	15.041	93.351	362.736	117.376	15.33	93.476
	0.004	669.847	299.81	14.803	93.245	3.906	0.0179	14.686	93.190	362.901	120.313	14.955	93.313
	0.006	670.167	309.866	14.323	93.018	3.908	0.0184	14.342	93.027	363.065	123.304	14.593	93.147
	0.008	670.487	320.091	13.865	92.788	3.910	0.0188	14.009	92.861	363.23	126.346	14.241	92.978
	0.01	670.807	330.511	13.428	92.553	3.912	0.0193	13.686	92.693	363.395	129.441	13.901	92.806
	range	1.441	45.414	2.139	1.023	0.008	0.0019	1.536	0.737	0.7412	13.513	1.6204	0.751
β=0.666	0.001	678.098	497.305	8.924	88.795	3.991	0.030	8.684	88.485	373.243	203.137	8.857	88.710
	0.002	678.098	497.305	8.924	88.795	3.991	0.030	8.684	88.485	373.243	203.137	8.857	88.710
	0.004	678.098	497.305	8.924	88.795	3.991	0.030	8.684	88.485	373.243	203.137	8.857	88.710
	0.006	678.098	497.305	8.924	88.795	3.991	0.030	8.684	88.485	373.243	203.137	8.857	88.710
	0.008	678.098	497.305	8.924	88.795	3.991	0.030	8.684	88.485	373.243	203.137	8.857	88.710
	0.01	678.098	497.305	8.924	88.795	3.991	0.030	8.684	88.485	373.243	203.137	8.857	88.710
	range	0	0.00	0.00	0	0	0	0	0	0	0.00	0.00	0
β=0.90	0.001	691.952	896.166	4.952	79.808	4.124	0.055	4.800	79.170	388.964	367.374	4.897	79.583
	0.002	691.728	884.28	5.019	80.076	4.123	0.054	4.846	79.366	388.848	363.816	4.945	79.781
	0.004	691.28	860.809	5.155	80.605	4.120	0.053	4.939	79.755	388.618	356.779	5.043	80.172
	0.006	690.831	837.739	5.297	81.124	4.118	0.052	5.035	80.139	388.387	349.849	5.143	80.557
	0.008	690.383	815.076	5.445	81.635	4.115	0.051	5.133	80.518	388.157	343.021	5.245	80.936
	0.01	689.935	792.804	5.598	82.137	4.113	0.050	5.233	80.893	387.926	336.299	5.350	81.310
	range	2.017	103.362	0.645	2.328	0.011	0.004	0.432	1.723	1.037	31.075	0.452	1.727

Table 17: Sensitivity of BHD to Changes in θ under HY (different weights)

		BHD/GBP				BHD/JPY				BHD/CHF			
	θ	V_x (Max)	Var. (V_x)	VR	VD (%)	V_x (Max)	Var. (V_x)	VR	VD (%)	V_x (Max)	Var. (V_x)	VR	VD (%)
β=0.10	0.001	67.011	0.150	299.477	99.666	0.3814	8.9E-06	313.349	99.680	34.648	0.060	318.875	99.686
	0.002	67.068	0.193	232.947	99.570	0.3818	1.1E-05	260.563	99.616	34.677	0.073	262.885	99.619
	0.004	67.181	0.298	151.038	99.337	0.3824	1.5E-05	187.005	99.465	34.735	0.103	185.329	99.460
	0.006	67.293	0.427	105.573	99.052	0.3830	2E-05	139.942	99.285	34.792	0.141	136.444	99.267
	0.008	67.406	0.579	77.911	98.716	0.3837	2.6E-05	108.307	99.076	34.850	0.184	104.128	99.039
	0.01	67.519	0.754	59.773	98.327	0.3843	3.2E-05	86.200	98.839	34.908	0.234	81.900	98.779
	range	0.507	0.604	239.704	1.339	0.002	2.3E-05	227.148	0.840	0.259	0.174	236.974	0.907
β=0.50	0.001	69.339	2.898	15.568	93.576	0.4048	0.00018	15.101	93.378	37.409	1.243	15.471	93.536
	0.002	69.355	2.948	15.303	93.465	0.4049	0.00019	14.920	93.297	37.417	1.259	15.281	93.456
	0.004	69.388	3.050	14.791	93.239	0.4050	0.00019	14.568	93.135	37.434	1.290	14.909	93.292
	0.006	69.422	3.153	14.305	93.009	0.4052	0.0002	14.227	92.971	37.451	1.322	14.549	93.126
	0.008	69.455	3.259	13.841	92.775	0.4054	0.0002	13.897	92.804	37.468	1.355	14.199	92.957
	0.01	69.488	3.367	13.398	92.536	0.4056	0.00021	13.577	92.634	37.485	1.388	13.861	92.785
	range	0.149	0.469	2.169	1.040	0.0008	2.1E-05	1.523	0.743	0.076	0.144	1.610	0.750
β=0.666	0.001	70.238	5.053	8.927	88.798	0.414	0.0003	8.614	88.392	38.521	2.179	8.829	88.674
	0.002	70.238	5.053	8.927	88.798	0.414	0.0003	8.614	88.392	38.521	2.179	8.829	88.674
	0.004	70.238	5.053	8.927	88.798	0.414	0.0003	8.614	88.392	38.521	2.179	8.829	88.674
	0.006	70.238	5.053	8.927	88.798	0.414	0.0003	8.614	88.392	38.521	2.179	8.829	88.674
	0.008	70.238	5.053	8.927	88.798	0.414	0.0003	8.614	88.392	38.521	2.179	8.829	88.674
	0.01	70.238	5.053	8.927	88.798	0.414	0.0003	8.614	88.392	38.521	2.179	8.829	88.674
	range	0	0.00	0.00	0	0	0.00	0	0	0	0	0	0
β=0.90	0.001	71.666	9.105	4.955	79.818	0.428	0.00058	4.762	79.000	40.17	3.941	4.881	79.516
	0.002	71.643	8.982	5.022	80.090	0.428	0.00058	4.807	79.198	40.158	3.903	4.929	79.714
	0.004	71.596	8.740	5.161	80.626	0.427	0.00057	4.899	79.590	40.134	3.828	5.026	80.105
	0.006	71.550	8.503	5.306	81.153	0.427	0.00056	4.994	79.976	40.110	3.754	5.125	80.491
	0.008	71.503	8.269	5.455	81.671	0.427	0.00055	5.091	80.358	40.086	3.681	5.227	80.871
	0.01	71.457	8.040	5.611	82.179	0.426	0.00054	5.190	80.735	40.063	3.609	5.332	81.245
	range	0.209	1.065	0.656	2.361	0.001	4.8E-05	0.428	1.734	0.106	0.332	0.450	1.728

Figure: 7VR and VD under RS for GCC Currencies against GBP

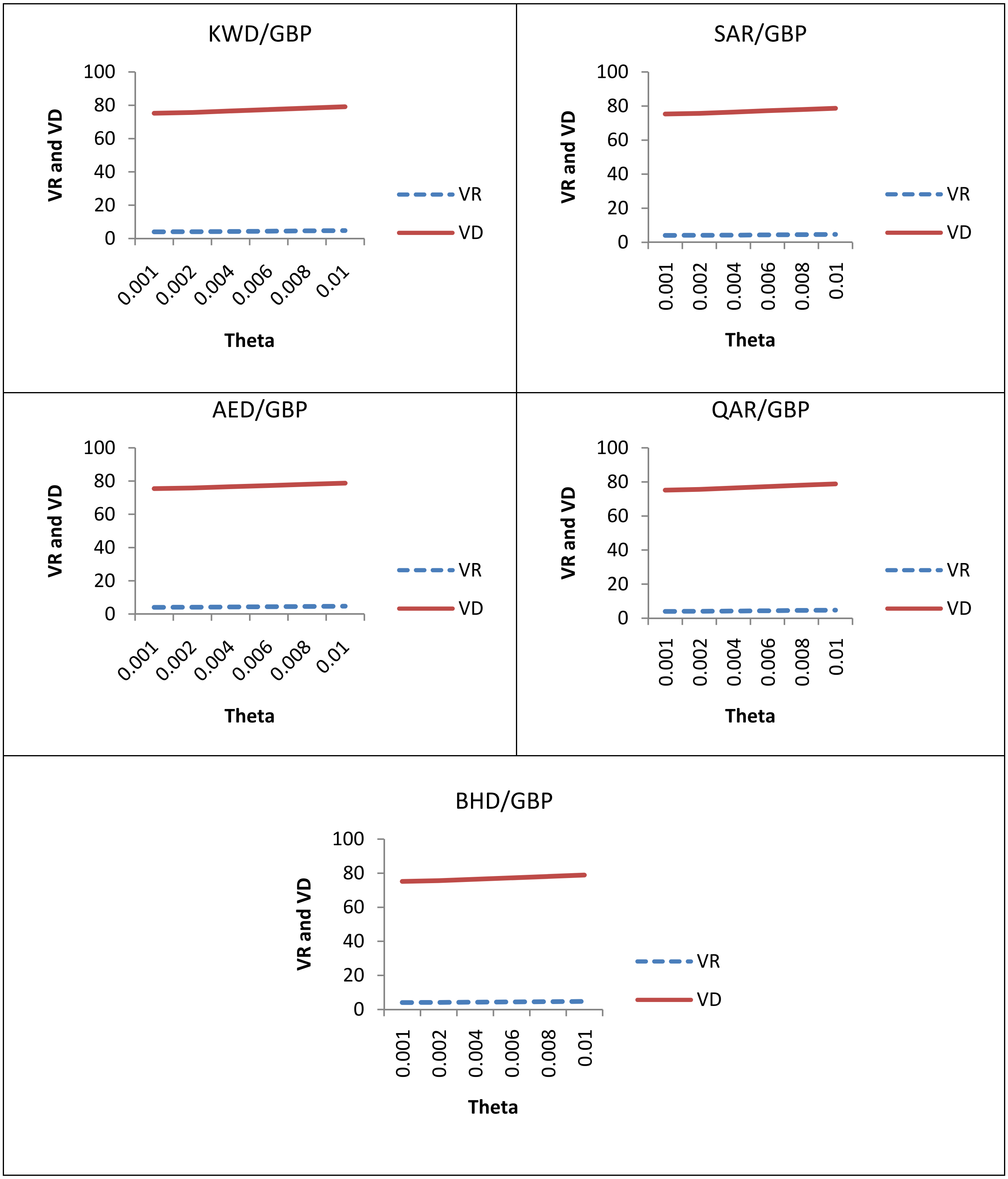

Figure 8: VR and VD under RS for GCC Currencies against JPY

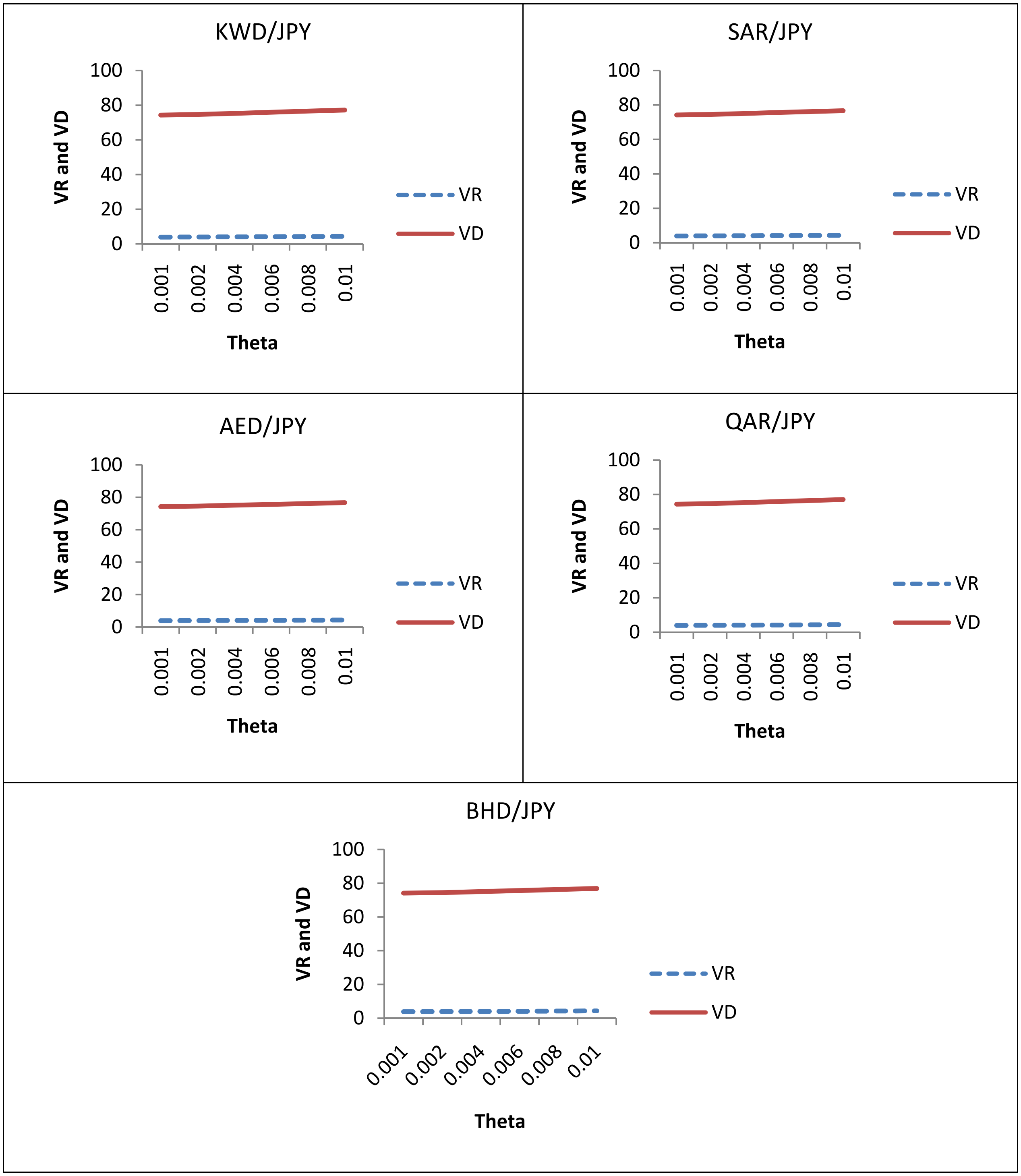

Figure 9: VR and VD under RS for GCC Currencies against CHF

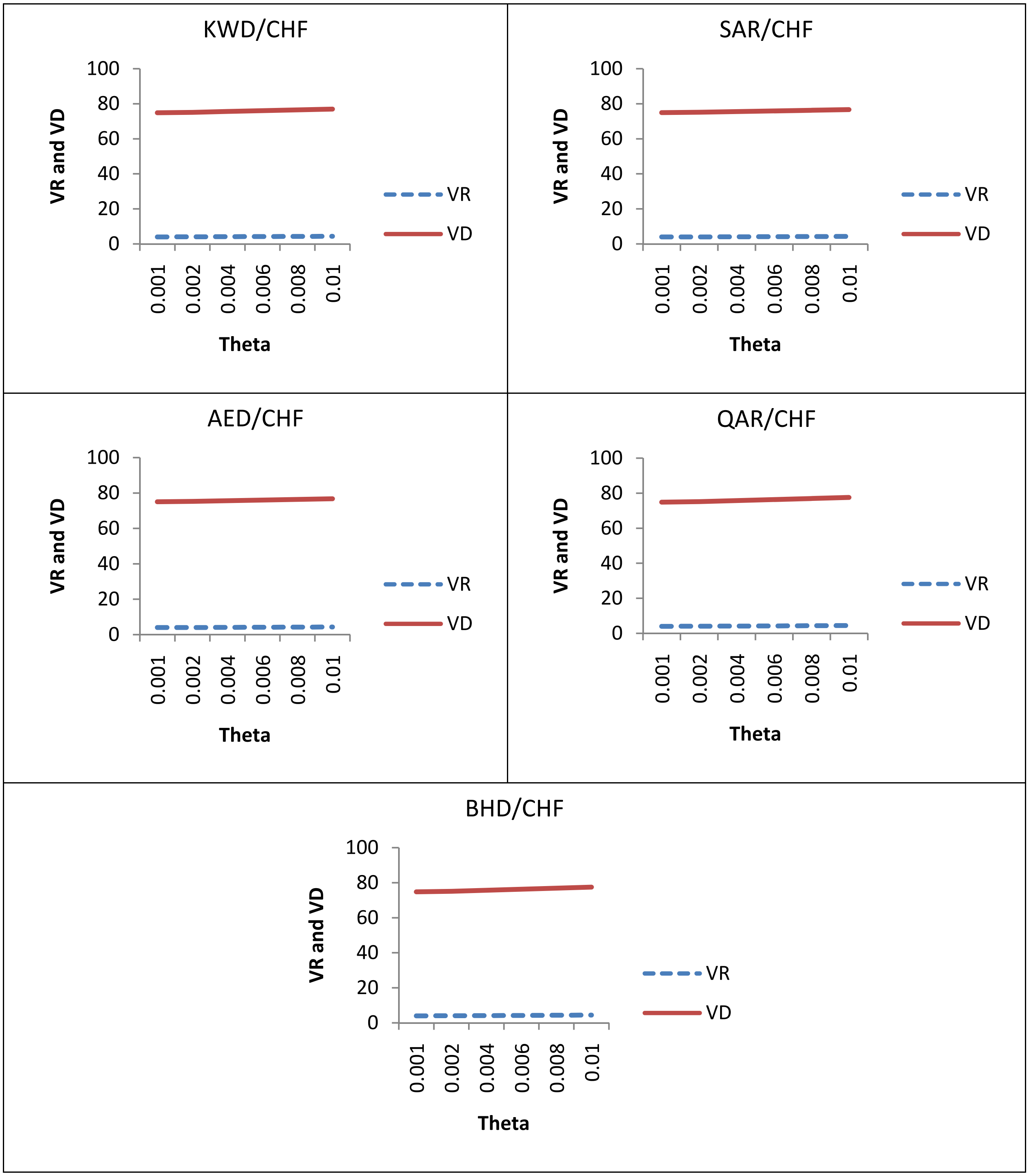

Figure 10: VR and VD under CC for GCC Currencies against GBP

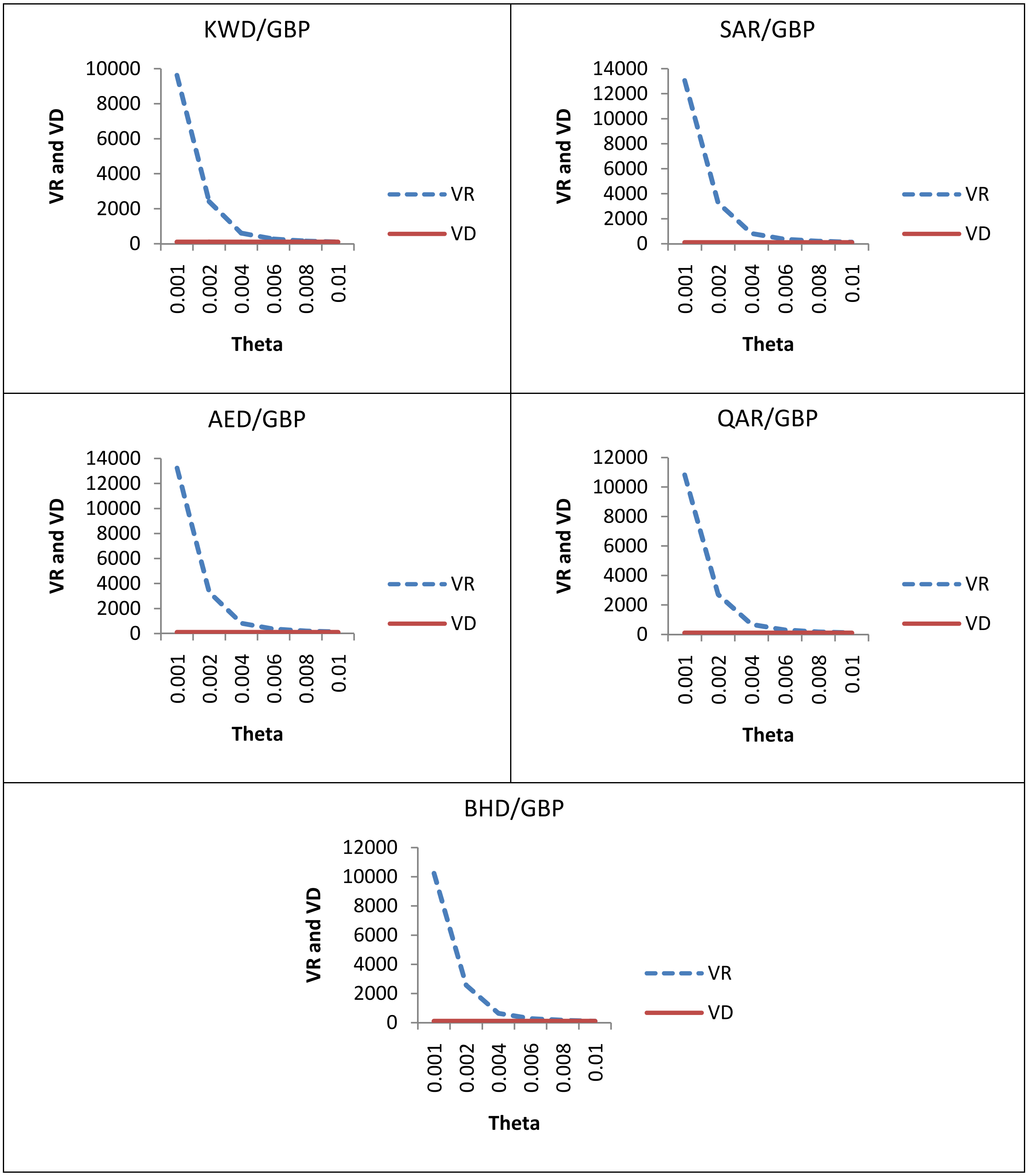

Figure 11: VR and VD under CC for GCC Currencies against JPY

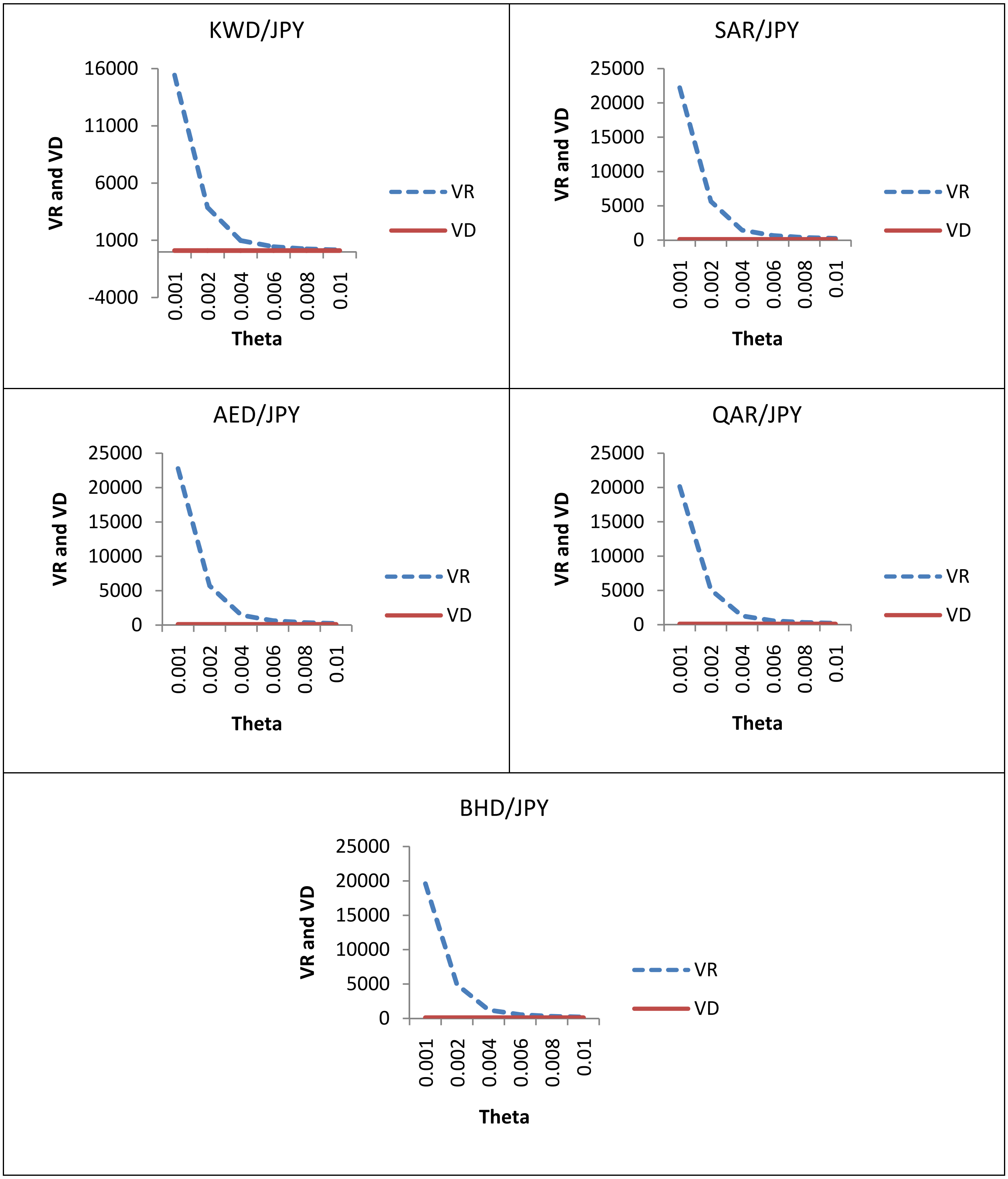

Figure 12: VR and VD under CC for GCC Currencies against CHF

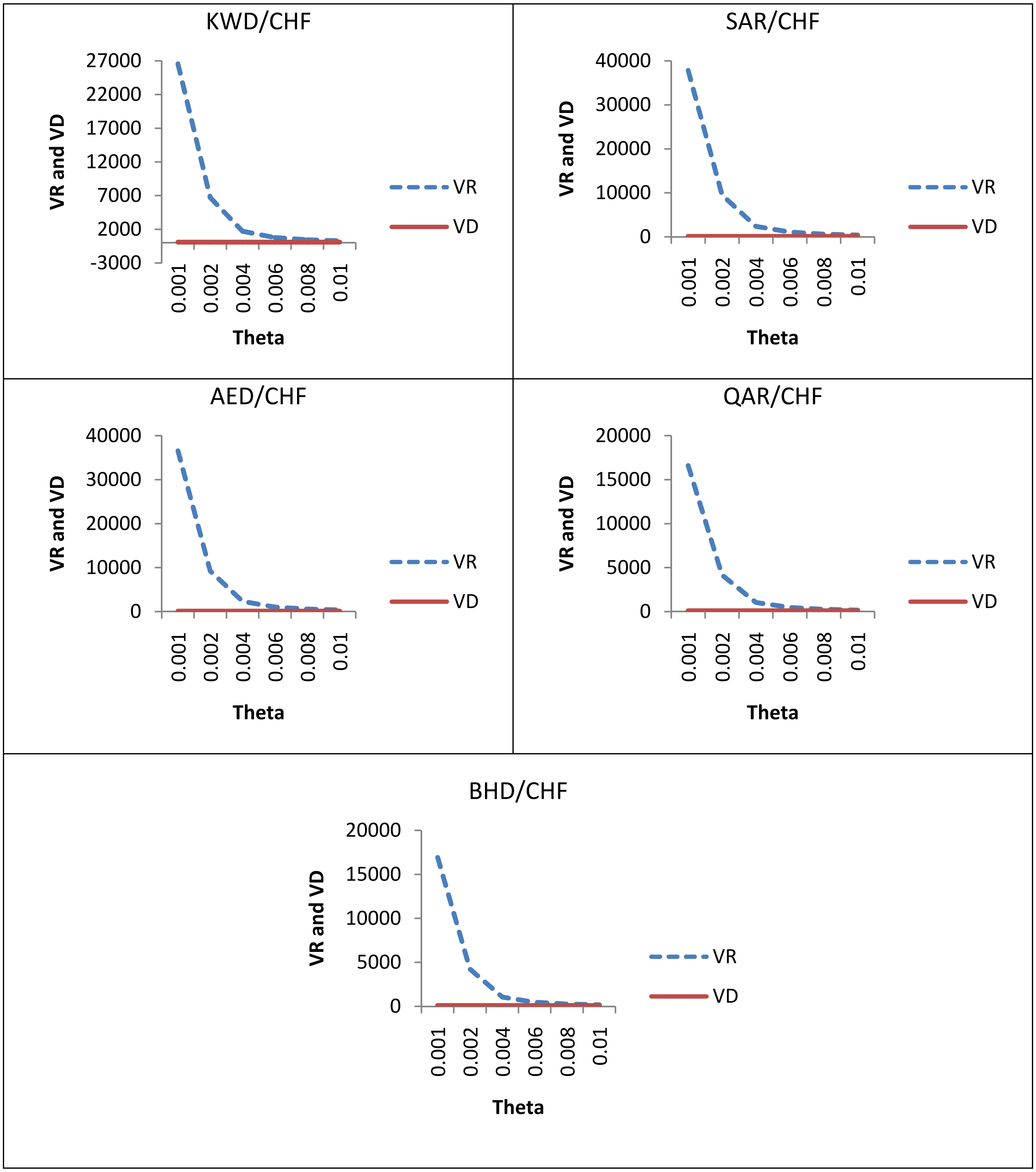

Figure 13: VR and VD under HY for GCC Currencies against GBP (equal weights)

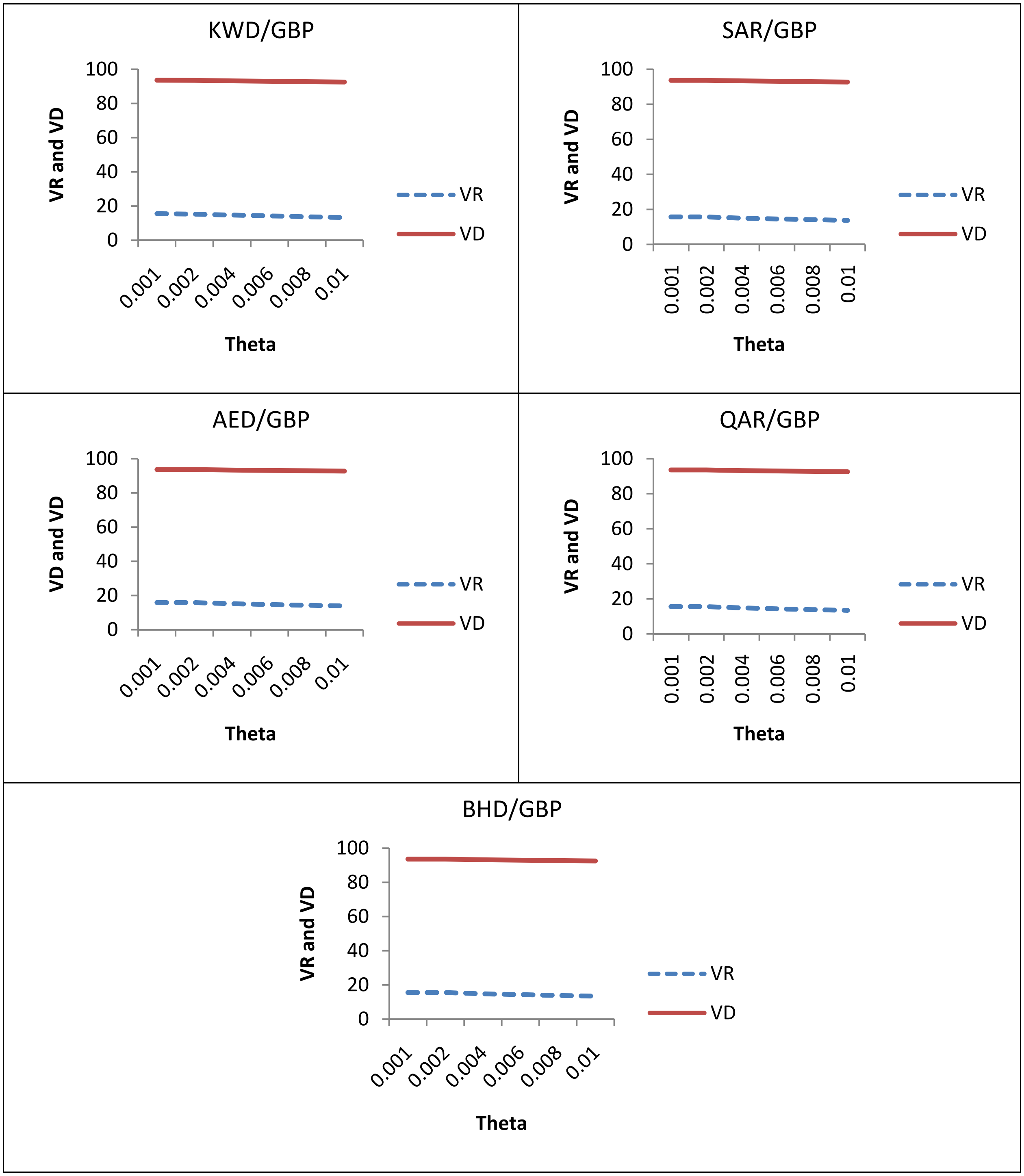

Figure 14: VR and VD under HY for GCC Currencies against JPY (equal weights)

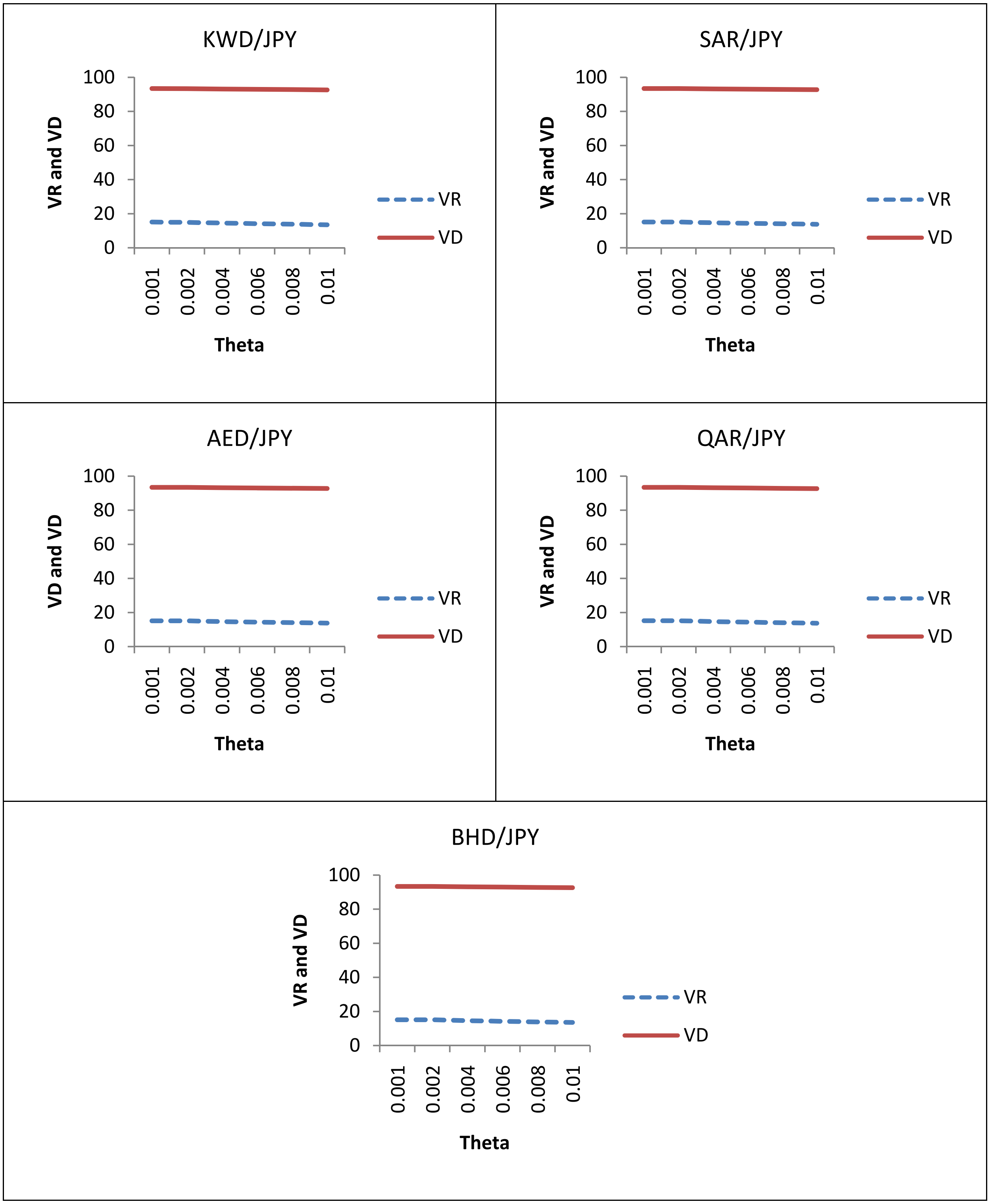

Figure 15: VR and VD under HY for GCC Currencies against CHF (equal weights)