Chapter 4 – Data Analysis

4.1 Test of Hypotheses

The objective of this study is to evaluate whether the hedging effectiveness for exchange-traded derivatives is superior to OTC derivatives, more specifically, Forwards. Data were analyzed to test the hypotheses. It needs to be stressed here that even with notional hedges, the data used were actual in all instances, with due adjustments for financing and transaction costs, as presented Appendix-2. The detailed calculation for exchange rates realized under Forwards, Futures and Options hedges is presented in Appendix-3.

4.2 Futures versus Forwards (US$ receivable - exporter)

The first hypothesis is that hedging with Futures contracts provides superior outcomes in terms of the exchange rate compared to Forward contracts, in hedging US$ exposure of an exporter. The exchange rates realized, notionally and actually, forms the basis of comparison for effectiveness. The hypothesis, as stated below, was tested using Paired t-test (one-tailed):

H_0: $\mu_{\text{diff-Fut-Forw}}$ (US$ receivable) $= 0$

H_1: $\mu_{\text{diff-Fut-Forw}}$ (US$ receivable) > 0

$\mu_{\text{diff-Fut-Forw}}$ (US$ receivable) is the mean difference between the exchange rate realized using the actual Forward hedge and the notional Futures hedge for US$ receivable. Data for the hypothesis are in Appendix – 2, Table 2A.1

The statistics for the paired t-test for comparison of the exchange rates realized using the Forward hedge and the Futures hedge for US$ receivable are in Table 4.1.

Table 4.1 Statistics of the paired t-test for comparison of exchange rate realized using the Forward hedge and the notional Futures hedge for US$ receivable

Statistic	Forward Hedge	Futures Hedge
Mean	64.7903	64.9190
Variance	9.6019	9.4820
Observations	643	643
Pearson Correlation		0.9966542
Hypothesized Mean Difference		Nil
Df		642
t Stat		12.87324658
P(T≤t) one-tail		3.3595E-34
t Critical one-tail	Right tail	1.647230549

The mean exchange rate realized in the notional Futures hedge is Rs. 64.9190 / US$ compared to exchange rate of Rs. 64.7903/US$ with the actual Forward hedge. The computed t-stat 12.8732 is greater than the t-stat of 1.6472 (at significance level of 5%). P one-tail (Right tail) observed (3.3595E-34) is less than 0.05. The null hypothesis is rejected and the alternative hypothesis is accepted. The difference in the mean exchange rate realized by employing a Futures hedge compared to the Forward hedge is Rs. 0.1287 /US$. Thus, we conclude that a currency hedge using Futures is more effective than a Forward Hedge. The results were obtained using Microsoft Xcel – Data analysis feature.

4.3 Options versus Forwards (US$ receivable - exporter)

The second hypothesis is that hedging with Options, more specifically, buying put options on the US$, provides a better outcome compared to Forwards when hedging US$ exposure of an exporter. The hypothesis as stated below was tested using Paired t-test (one-tailed):

H_0: $\mu_{\text{diff-Opt-Forw}}$ (US$ receivable) $= 0$

H_1: $\mu_{\text{diff-Opt-Forw}}$ (US$ receivable) > 0

$\mu_{diff\text{-}Opt\text{-}Forw}$ (US$ receivable) is the mean difference between the exchange rate realized under the actual Forward hedge and the notional Option hedge for US$ receivable.

Data for the hypothesis are in Appendix – 2, Table 2A.2

The statistics of the paired t-test for comparison of exchange rates realized using the Option hedge and Forward hedge for US$ receivable are mentioned below in Table 4.2.

Table 4.2 Statistics of the paired t-test for comparison of exchange rate realized using the notional Put Option hedge and Forward hedge for US$ receivable

Statistic	Forward Hedge	Option Hedge (Long Put Option)
Mean	63.2810	63.6015
Variance	7.8245	8.4662
Observations	239	239
Pearson Correlation		0.986578056
Hypothesized Mean Difference		Nil
Df		238
t Stat		10.3061717
P(T≤t) one-tail		3.91837E-21
t Critical one-tail	(Right tail)	1.651281164

The mean exchange rate realized in the notional Put Option hedge is Rs. 63.6015/ US$ compared to the actual exchange rate of Rs. 63.2810/US$ with the Forward hedge. The computed t-stat 10.3061 is greater than the t-stat of 1.6512 (at significance level of 5%). P one-tailed (Right tail) observed (3.91837E-21) is less than 0.05. The null hypothesis is rejected and the alternative hypothesis is accepted. The difference in the mean exchange rate realized using the option hedge compared to Forward hedge is Rs. 0.3205 /US$. Therefore, we conclude that the currency hedge using the Put Option would have yielded a higher exchange rate for an exporter compared to a Forward hedge.

4.4 Futures versus Forwards (US$ payable - importer)

The third hypothesis is that hedging with Futures yields superior outcomes, in terms of exchange rates compared to Forwards in hedging US$ exposures of an importer. The hypothesis as stated below was tested using Paired t-test (one-tailed – left tail):

H_0: $\mu_{\text{diff-Fut-Forw}}$ (US$ payable) = 0

H_1: $\mu_{\text{diff-Fut-Forw}}$ (US$ payable) < 0

$\mu_{\text{diff-Fut-Forw}}$ (US$ payable) is the mean difference between the exchange rate realized using the notional Futures hedge and the actual Forward hedge for US$ payable.

Data for the hypothesis are in Appendix – 2, Table 2A.3.

The statistics of the paired t-test for comparison of the exchange rate realized with the actual Forward hedge versus that of the notional Futures hedge for US$ payable are mentioned in Table 4.3.

Table 4.3 Statistics of the paired t-test for comparison of exchange rate realized with the Forward hedge versus the notional Futures hedge for US$ payable

Statistic	Forward Hedge	Futures Hedge
Mean	65.9577	65.4947
Variance	0.4932	0.6563
Observations	64	64
Pearson Correlation		0.976649185
Hypothesized Mean Difference		Nil
Df		63
t Stat		-18.95139769
P(T≤t) one-tail		5.13207E-28
t Critical one-tail	(negative for left tailed test)	1.669402222

The mean exchange rate realized using the Futures hedge is Rs. 65.4947/ US$ compared to the exchange rate of Rs. 65.9577/ US$ with the Forward hedge. The computed t-stat is -18.951 compared to t-stat of -1.6694 (at significance level of 5% - left tail). P one-tail (left

tail) observed (5.13207E-28) is less than 0.05.The null hypothesis is rejected and the alternative hypothesis is accepted. The difference in the mean exchange rate realized using the Futures hedge compared to the Forward hedge is -0.4630 /US$. An importer would desire to buy the US$ at lower exchange rates. Apparently, a currency hedge using Currency Futures results in a lower exchange rate for importers compared to the Forward hedge.

4.5 Options versus Forwards (US$ payable - importer)

The fourth hypothesis is that hedging with Options, that is, buying calls on the US$, provides better exchange rates compared to Forwards in hedging US$ exposure of an importer.

The hypothesis as stated below was tested using Paired t-test (one-tailed – left tail):

H_0: $\mu_{\text{diff-Opt-Forw}}$ (US$ payable) $= 0$

H_1: $\mu_{\text{diff-Opt-Forw}}$ (US$ payable) < 0

$\mu_{\text{diff-Opt-Forw}}$ (US$ payable) is the mean difference between the exchange rate realized using a notional Call Option hedge and the actual Forwards hedge for US$ payable.

Data for the hypothesis are in Appendix – 2, Table 2A. 4.

The statistics of the paired t-test for comparison of exchange rate realized using the Option hedge and Forward hedge for US$ payable are mentioned below in Table 4.4.

Table 4. 4 Statistics of the paired t-test for comparison of exchange rate realized using the notional Option hedge and Forward hedge for US$ payable

Statistic	Forward Hedge	Option Hedge (Long Call Option)
Mean	66.1325	65.4708
Variance	1.3000	1.8273
Observations	24	24
Pearson Correlation		0.982786861
Hypothesized Mean Difference		Nil
Df		23
t Stat		-10.36344277
P(T ≤ t) one-tail		1.94068E-10
t Critical one-tail	(negative for left tailed test)	1.713871517

The mean exchange rate realized using the Call Option hedge is Rs. 65.4708/ US$ compared to the exchange rate of Rs. 66.1325/ US$ with the Forward hedge. The t-stat observed of -10.3634 compared to t-stat of -1.7138(at significance level of 5% - left tail). P one-tail (left tail) observed (1.94068E-10) is less than 0.05. The null hypothesis is rejected and the alternative hypothesis is accepted. The difference in the mean exchange rate realized using a Call Option hedge compared to the Forward hedge is - 0.6616 /US$. Again, an importer would be desirous of buying the US$ at lower exchange rates. The results suggest that a currency hedge using a Call Option yields lower exchange rates for importers compared to a Forwards hedge.

4.6 Futures versus Forwards (Euro receivable - exporter)

The fifth hypothesis is that hedging with Futures yields better exchange rates compared to hedging with Forwards for Euro exposures of an exporter.

The hypothesis as stated below was tested using Paired t-test (one-tailed):

H_0: $\mu_{\text{diff-Fut-Forw}}$ (Euro receivable) $= 0$

H_1: $\mu_{\text{diff-Fut-Forw}}$ (Euro receivable) > 0

$\mu_{\text{diff-Fut-Forw}}$(Euro receivable) is the mean difference between the exchange rate realized using the Futures hedge and Forwards hedge for Euro receivable.

Data for the hypothesis are presented in Appendix – 2, Table 2A. 5

The statistics of the paired t-test for comparison of exchange rates realized using the Futures hedge and Forward hedge for Euro receivables are presented in Table 4.5.

Table 4.5 Statistics of the paired t-test for comparison of exchange rate realized in the Forward hedge and the notional Futures hedge for Euro receivables

Statistic	Forward Hedge	Futures Hedge
Mean	75.1504	75.5523
Variance	33.0184	30.1280
Observations	204	204
Pearson Correlation		0.996606167
Hypothesized Mean Difference		Nil
Df		203
t Stat		10.84276247
P(T≤t) one-tail		3.32013E-22
t Critical one-tail	(Right tail)	1.652394461

The mean exchange rate realized in the Futures hedge is Rs. 75.5523 / Euro compared to the exchange rate of Rs. 75.1504/ Euro with the Forward hedge. The t-stat observed (10.8427) is greater than t-stat of 1.6523 (at significance level of 5%). P one-tail (Right tail) observed (3.32013E-22) is less than 0.05. The null hypothesis is rejected and the alternative hypothesis is accepted. The difference in mean exchange rates realized using the Futures hedge compared to the Forward hedge is Rs. 0.4019 / Euro. Therefore, we infer that a currency hedge using Futures is more effective than a Forward Hedge for exporters having Euro receivables.

The five preceding hypotheses compared the hedging effectiveness of exchange-traded Options and Futures versus OTC Forwards. The next two hypotheses compare the hedging effectiveness of Options with Futures. In these instances, both involve notional hedges.

4.7 Options versus Futures (US$ receivable - exporter)

The sixth hypothesis states that hedging with Options provide better exchange rates compared to Futures in hedging US$ exposures of an exporter. The hypothesis as stated below was tested using Paired t-test (one tailed):

H_0: $\mu_{\text{diff-Opt-Fut}}$ (US$ receivable) $= 0$

H_1: $\mu_{\text{diff-Opt-Fut}}$ (US$ receivable) > 0

$\mu_{\text{diff-Opt-Fut}}$ (US$ receivable) is the mean difference between the exchange rates realized using the Options hedge and Forwards hedge for US$ receivable.

Data for the hypothesis are in Appendix – 2, Table 2A.6.

The statistics of the paired t-test for comparison of exchange rate realized using the Option hedge and Futures hedge for US$ receivable are presented in Table 4.6.

Table 4. 6 Statistics of the paired t-test for comparison of exchange rates realized by notionally employing the Option hedge and the Futures hedge for US$ receivable

Statistic	Options Hedge (Put Option)	Futures Hedge
Mean	63.6015	63.5343
Variance	8.4662	7.6587
Observations	239	239
Pearson Correlation	0.983624249	
Hypothesized Mean Difference	Nil	
Df	238	
t Stat	1.949886102	
P(T≤t) one-tail	0.026181998	
t Critical one-tail	1.651281164	Right tail

The mean exchange rate realized with the Put Option hedge is Rs. 63.6015/ US$ compared to the exchange rate of Rs. 63.5344/ US$ with a Futures hedge. The t-stat observed (1.9498) is greater than t-stat of 1.6512 (at significance level of 5%). P- one-tail (Right tail) observed (0.02618) is less than 0.05. The null hypothesis is rejected and the alternative hypothesis is accepted. The difference in the mean exchange rate realized using the Option hedge compared to the Futures hedge is Rs. 0.0671 /US$. The results suggest that a currency hedge using the Put Option yields higher exchange rates for exporters compared to the Futures hedge.

4.8 Options versus Futures (US$ payable - importer)

The seventh hypothesis is that Call Options provide better exchange rates compared to Futures for hedging US$ exposures of an importer. The hypothesis as stated below was tested using Paired t-test (one tailed):

H_0: $\mu_{\text{diff-Opt-Fut}}$ (US$ payable) $= 0$

H_1: $\mu_{\text{diff-Opt-Fut}}$ (US$ payable) < 0

$\mu_{\text{diff-Opt-Fut}}$ (US$ payable) is the mean difference between the exchange rate realized using the notional Futures hedge versus the notional Option hedge for US$ payable

Data for the hypothesis are presented in Appendix – 2, Table 2A.7.

The statistics of the paired t-test for comparison of exchange rate realized using the Options hedge and Futures hedge for US$ payable are mentioned in Table 4.7.

Table 4.7 Statistics of the paired t-test for comparison of exchange rates realized using the notional Option hedge and the Futures hedge for US$ payable

Statistic	Option Hedge (Call Option)	Futures Hedge
Mean	65.4708	65.7922
Variance	1.8273	1.5950
Observations	24	24
Pearson Correlation	0.973964207	
Hypothesized Mean Difference	Nil	
Df	23	
t Stat	-5.059797546	
P(T≤t) one-tail	2.01105E-05	
t Critical one-tail	1.713871517	(negative for left tailed test)

The mean exchange rate realized in the Call Option hedge is Rs. 65.4078 / US$ compared to exchange rate of Rs. 65.7922/ US$ with the Futures hedge. The t-stat observed (-5.0597) is less than t-stat of -1.7138 (at significance level of 5%). P-one-tail (left tail) observed (2.01105E-05) is less than 0.05. The null hypothesis is rejected and the alternative hypothesis is accepted. The difference in the mean exchange rate realized using Option hedge compared to the Futures hedge is Rs. 0.3213/US$. Thus, the result suggests that a currency hedge using Call Options yields better exchange rates for importer compared to the Futures hedge.

4.9 Test of Proportion - Futures versus Forwards (US$ receivable – exporter)

A simple analysis of the observations reveals that an exporter having US$ receivable would realize a better exchange rate in 459 instances out of 643, using the Futures hedge compared to the Forward hedge. To check if a Futures hedge would be more advantageous compared to a Forward currency hedge, the Z-test of proportion was employed. The hypothesis for the test of proportion for an exporter having US$ receivable is formulated as:

$H_{0:}$ P = 0.50

$H_{1:}$ P > 0.50

'P' is the proportion of transactions in which the exchange rate realized using a Futures hedge is greater (better) than with the Forward hedge.

Data for the hypothesis are in Appendix – 2, Table 2A.1

The Z-test of proportion was used to test the Null hypothesis and the summary of statistics is presented in Table 4.8.

Table 4.8 Statistics of Z-test of proportion for significance of Futures hedge proportion (US$ - receivable)

Observations	643
No. of observations in which exchange rate realized using Futures Hedge is greater than the rate realized using a Forward hedge	459
Proportion	0.7138
Hypothesized Proportion	0.50
Standard error	0.017823738
Z-Value	11.998
Significance Level	0.05
Z-Critical (One Tail - Right)	1.6449
p-value	0.000

Accordingly, the null hypothesis is rejected at 5% significance level and the alternative hypothesis is accepted.

4.10 Test of Proportion - Options versus Forwards (US$ receivable – exporter)

An analysis of the observations reveals that in 185 instances out of 239, an exporter having US$ receivable benefits by realizing a better exchange rate by using Put Option hedge compared to the Forward hedge. To test the statistical significance, the Z-test of proportion was utilized. It would be concluded that the Option hedge would be preferable to the Forward hedge, if the advantage manifests in more than fifty per cent of the transactions. Accordingly, the hypothesis for test of proportion for an exporter having US$ receivable is formulated as:

$H_{0:}$ $P = 0.50$

$H_{1:}$ $P > 0.50$

'P' is the proportion of transactions in which the exchange rate realized using an Option hedge is better than with a Forward hedge.

Data for the hypothesis is in Appendix – 2, Table 2A.2

Z-test of proportion was carried out to test the Null hypothesis and the summary of statistics is presented in Table 4.9

Table 4.9 Statistics for Z-test of proportion for significance of Options hedge proportion (US$ - receivable)

Observations	239
No. of observations in which the exchange rate realized using a Option (Put) Hedge is greater than the rate realized using a Forward hedge	185
Proportion	0.7741
Hypothesized Proportion	0.50
Standard error	0.02705116
Z-Value	10.131
Significance Level	0.05
Z-Critical (One Tail - Right)	1.6449
p-value	0.000

Accordingly, the null hypothesis is rejected at 5% significance level and the alternative hypothesis is accepted.

4.11 Test of Proportion - Futures versus Forwards (US$ payable – importer)

An importer having US$ payable who employs a Futures hedge compared to the Forward hedge is seemingly advantageously placed in terms of a better exchange rate in 62 out of 64 observations. To check if a Futures hedge is advantageous vis-à-vis the Forward hedge, the Z-test of proportion was applied. It would be inferred that the Futures hedge performs better than the Forward hedge if the advantage occurs in more than fifty per cent of the transactions. In case of importers, an advantage in Futures hedge means that the exchange rate realized under the hedge is lower than the exchange rate realized using a Forward hedge.

The hypothesis for test of proportion for importer having US$ payable is formulated as:

$H_{0:}$ $P = 0.50$

$H_{1:}$ $P > 0.50$

'P' is the proportion of transactions for which the exchange rate realized using Futures hedge is better than with a Forward hedge.

Data for the hypothesis is in Appendix – 2, Table 2A.3

Z-test of proportion was carried out to test the Null hypothesis and summary of statistics are highlighted in Table 4.10.

Table 4.10 Statistics of Z-test of proportion for significance of Futures hedge proportion (US$ - payable)

Observations	64
No. of observations in which the exchange rate realized using a Futures Hedge is less than the rate realized using a Forward hedge	62
Proportion	0.9688
Hypothesized Proportion	0.50
Standard error	0.02174908
Z-Value	21.553
Significance Level	0.05
Z-Critical (One Tail - Right)	1.6449
p-value	0.000

Accordingly, the null hypothesis is rejected at 5% significance level and the alternative hypothesis is accepted.

4.12 Test of Proportion - Futures versus Forwards (Euro receivable – exporter)

An exporter having Euro receivable apparently has an advantage of realizing a better exchange rate in 171 instances out of 204, by using a Futures hedge compared to a Forward hedge. To check the statistical significance of the same, the Z-test of proportion was utilized. It would be concluded that Futures hedge is preferable to the Forward hedge if the advantage occurs in more than fifty per cent of the transactions. In case of exporters, the advantage in a Futures hedge means that the exchange rate realized under the hedge is greater than the exchange rate realized using a Forward hedge.

Hypothesis for test of proportion for exporter having Euro receivable is formulated as:

$H_{0:}$ $P = 0.50$

$H_{1:}$ $P > 0.50$

'P' is the proportion of transactions in which the exchange rate realized using the Futures hedge is better than with a Forward hedge.

Data for the hypothesis are in Appendix – 2, Table 2A.5

Z-test of proportion was carried out to test the Null hypothesis and summary of statistics are presented in Table 4.11:

Table 4.11 Statistics of Z-test of proportion for significance of Futures hedge proportion (EURO - receivable)

Observations	204
No. of observations in which the exchange rate realized using a Futures Hedge is greater than the rate realized using a Forward hedge	171
Proportion (%)	0.8382
Hypothesized Proportion	0.50
Standard error	0.025781595
Z-Value	13.119
Significance Level	0.05
Z-Critical (One Tail - Right)	1.6449
p-value	0.000

Accordingly, the null hypothesis is rejected at 5% significance level and the alternative hypothesis is accepted.

4.13 Summary of the Test Statistics

A summary of the aforementioned hypotheses and the related results of the tests conducted is presented in Table 4.12 and Table 4.13:

Table 4.12 Summary of hypotheses and statistics for the paired t-tests

Paired t-test conducted for:	**Critical t-statistic (5% significance level)**	**Observed t-statistic**	**Result**
H_0: $\mu_{\text{diff-Fut-Forw}}$ (US$ receivable) $= 0$ H_1: $\mu_{\text{diff-Fut-Forw}}$ (US$ receivable) > 0	1.647230549	12.87324658	Null hypothesis is rejected and the alternative hypothesis is accepted
H_0: $\mu_{\text{diff-Opt-Forw}}$ (US$ receivable) $= 0$ H_1: $\mu_{\text{diff-Opt-Forw}}$ (US$ receivable) > 0	1.651281164	10.3061717	Null hypothesis is rejected and the alternative hypothesis is accepted
H_0: $\mu_{\text{diff-Fut-Forw}}$ (US$ payable)$= 0$ H_1: $\mu_{\text{diff-Fut-Forw}}$ (US$ payable) < 0	-1.669402222	-18.95139769	Null hypothesis is rejected and the alternative hypothesis is accepted
H_0: $\mu_{\text{diff-Opt-Forw}}$ (US$ payable) $= 0$ H_1: $\mu_{\text{diff-Opt-Forw}}$ (US$ payable) < 0	-1.713871517	-10.36344277	Null hypothesis is rejected and the alternative hypothesis is accepted
H_0: $\mu_{\text{diff-Fut-Forw}}$ (Euro receivable) $= 0$ H_1: $\mu_{\text{diff-Fut-Forw}}$ (Euro receivable) > 0	1.652394461	10.84276247	Null hypothesis is rejected and the alternative hypothesis is accepted

Table 4.13 Summary of hypotheses and statistics for the Z-test of proportion

Z-test of proportion conducted for:	**Critical Z-statistic (5% significance level)**	**Observed Z-statistic**	**Result**
Futures versus Forwards (US$ receivable by exporter) $H_{0:}$ P = 0.50 $H_{1:}$ P > 0.50	1.6449	11.998	Null hypothesis is rejected and the alternative hypothesis is accepted
Options versus Forwards (US$ receivable by exporter) $H_{0:}$ P = 0.50 $H_{1:}$ P > 0.50	1.6449	10.131	Null hypothesis is rejected and the alternative hypothesis is accepted
Futures versus Forwards (US$ payable by importer) $H_{0:}$ P = 0.50 $H_{1:}$ P >0.50	1.6449	21.553	Null hypothesis is rejected and the alternative hypothesis is accepted
Futures versus Forwards (Euro receivable by exporter) $H_{0:}$ P = 0.50 $H_{1:}$ P > 0.50	1.6449	13.119	Null hypothesis is rejected and the alternative hypothesis is accepted