**APPENDICES**

**Appendix A: Summary on Hedging Effectiveness using BEKK GARCH Modelling**

| Authors | Type of Market | Data | Period | Method |
|---|---|---|---|---|
| Kavussanos and Visvikis(2008) | Athens Stock Index Futures | Daily and weekly | Sept 1999-Jun 2004 | VECM-BEKK X |
| Lee and Yoder (2007) | Corn (CBOT) Nickel (LME) | Weekly | Jan 1991-Dec 2004 | Intercept - Regime Switching BEKK |
| Switzer and El-Khoury (2006) | NYMEX-Crude Oil | Daily | Jan 1986-Apr 2005 | ECM-BEKK Asymmetric |
| Ford et al. (2005) | FKLI (Stock Index) | Daily | Dec 1995-Apr 2001 | Intercept-BEKK |
| Brooks et al. (2002) | FTSE100 | Daily | Jan 1995-Apr 1999 | VECM-BEKK-Asymmetric |
| Malo and Kanto (2005) | Nordic Electric Market | Daily | Jan 2002-Nov 2002 | BEKK, CCC and DCC |
| Moschini and Myers (2002) | Corn (CBOT) | Weekly | Jan 1976-Jun 1997 | VAR+ Seasonal effect-BEKK |
| Gagnon and Lypny (1998) | Canadian Bankers Accpt Futures | Weekly | Mar 1990-Mar 1994 | VECM-BEKK Asymmetric |

**Appendix B: Summary on Hedging Effectiveness using CCC and DCC GARCH Modelling.**

| Authors | Type of Market | Data | Period | Method |
|---|---|---|---|---|
| Malo and Kanto (2005) | Nordic Electric Market | Daily | Jan 2002-Nov 2002 | BEKK, CCC and DCC |
| Lien et al. (2000) | Three Currency Exchange Futures (BP, DM and JY)<br>Five Comm Futures (Soybean oil, wheat, crude oil, corn and cotton)<br>Stock Index Futures (NYSE and SP500) | Weekly | Jan 1988-Jun 1998 | VAR-CCC |
| Bera et al (1997) | Corn and Soybeans | Daily | Oct 1988- Dec 1989 | Intercept-(BGARCH, BEKK and CCC) |
| Park and Switzer (1995) | SP 500 and Toronto 35 index | Weekly | Jun 1988-Dec 1991 | ECM-CCC |

## Appendix C : The Autocorrelation function of the residuals for BEKK Model

| | | Residual Series | Squared Residuals |
|---|---|---|---|
| | Lags | Q-Statistic | Q-Statistic |
| | | **Mean Equation : Intercept** | |
| CPO | 1 | 37.541*** | 10.003*** |
| | 4 | 60.325*** | 23.467*** |
| | 10 | 101.776*** | 25.815** |
| FCPO | 1 | 0.537 | 1.438 |
| | 4 | 15.679** | 9.016* |
| | 10 | 39.133*** | 22.116** |
| | | **Mean Equation : VAR** | |
| CPO | 1 | 1.129 | 8.806** |
| | 4 | 6.878 | 10.197** |
| | 10 | 17.520* | 11.637 |
| FCPO | 1 | 0.264 | 0.417 |
| | 4 | 6.031 | 0.979 |
| | 10 | 7.844 | 14.814 |
| | | **Mean Equation : VECM** | |
| CPO | 1 | 2.731* | 1.796 |
| | 4 | 2.905 | 6.934 |
| | 10 | 22.745** | 8.483 |
| FCPO | 1 | 3.064* | 0.0545 |
| | 4 | 4.449 | 4.934 |
| | 10 | 18.931** | 18.200* |

*** represents 1 % level of significance

** represents 5 % level of significance

* represents 10 % level of significance

## Appendix D : The Autocorrelation function of the residuals for Constant Correlation Model

| | | Residual Series | Squared Residuals |
|---|---|---|---|
| | Lags | Q-Statistic | Q-Statistic |
| | | **Mean Equation : Intercept** | |
| CPO | 1 | 47.256*** | 3.151 |
| | 4 | 72.457 | 4.740 |
| | 10 | 112.393*** | 5.784 |
| FCPO | 1 | 0.953 | 0.0370 |
| | 4 | 16.520*** | 1.867 |
| | 10 | 45.550*** | 48.095*** |
| | | **Mean Equation : VAR** | |
| CPO | 1 | 0.958 | 1.9000 |
| | 4 | 8.845* | 9.008* |
| | 10 | 17.138 | 7.296 |
| FCPO | 1 | 1.9 | 0.365 |
| | 4 | 9.008* | 2.826 |
| | 10 | 12.132 | 32.209* |
| | | **Mean Equation : VECM** | |
| CPO | 1 | 1.028 | 3.800* |
| | 4 | 9.095* | 5.114 |
| | 10 | 26.008*** | 6.506 |
| FCPO | 1 | 1.596 | 0.442 |
| | 4 | 11.007** | 2.603 |
| | 10 | 25.61* | 29.103*** |

*** represents 1 % level of significance

** represents 5 % level of significance

* represents 10 % level of significance

## Appendix E: The Autocorrelation function of the residuals for Dynamic Conditional Correlation Model

| | | Residual Series | Squared Residuals |
|---|---|---|---|
| | Lags | Q-Statistic | Q-Statistic |
| | | **Mean Equation : Intercept** | |
| CPO | 1 | 47.377*** | 3.076* |
| | 4 | 72.887*** | 4.651 |
| | 10 | 113.039*** | 5.723 |
| FCPO | 1 | 0.999 | 0.458 |
| | 4 | 16.01** | 1.195 |
| | 10 | 44.563*** | 40.712*** |
| | | **Mean Equation : VAR** | |
| CPO | 1 | 0.282 | 3.67 |
| | 4 | 7.729 | 4.956 |
| | 10 | 15.694 | 6.746 |
| FCPO | 1 | 1.721 | 0.000007 |
| | 4 | 9.502** | 1.037 |
| | 10 | 12.015 | 24.283*** |
| | | **Mean Equation : VECM** | |
| CPO | 1 | 0.259 | 3.37* |
| | 4 | 7.961* | 4.587 |
| | 10 | 23.198** | 6.1999 |
| FCPO | 1 | 1.067 | 0.00142 |
| | 4 | 11.576** | 0.876 |
| | 10 | 25.015*** | 22.037** |

*** represents 1 % level of significance

** represents 5 % level of significance

* represents 10 % level of significance

## Appendix F: Minimum variance measurement results for BEKK

| Variance Specification : BEKK Model | | | | |
|---|---|---|---|---|
| | Hedging Ratio Estimation | Variance (UHP) | Variance (HP) | Percentage Risk Minimization (%) |
| **Outsample Forecasting** | | | | |
| **Mean Specification : Intercept** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.38 | 0.76 | 0.55 | 27.30% |
| 5 Days | 0.48 | 1.77 | 1.19 | 32.88% |
| 10 Days | 0.48 | 1.98 | 1.38 | 30.46% |
| 15 Days | 0.5 | 1.81 | 1.18 | 34.65% |
| 20 Days | 0.61 | 1.25 | 0.39 | 68.68% |
| **Mean Specification : VAR** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.61 | 1.32 | 0.79 | 40.21% |
| 5 Days | 0.53 | 1.93 | 1.24 | 35.94% |
| 10 Days | 0.53 | 1.84 | 1.13 | 38.93% |
| 15 Days | 0.48 | 1.87 | 1.23 | 34.19% |
| 20 Days | 0.49 | 1.93 | 1.3 | 32.77% |
| **Mean Specification : VECM** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.47 | 1.65 | 1.34 | 18.81% |
| 5 Days | 0.53 | 1.81 | 1.07 | 40.57% |
| 10 Days | 0.54 | 2.07 | 1.33 | 35.81% |
| 15 Days | 0.49 | 1.44 | 0.78 | 45.94% |
| 20 Days | 0.49 | 1.44 | 0.79 | 45.36% |

| Variance Specification : BEKK Model | | | | |
|---|---|---|---|---|
| | **Hedging Ratio Estimation** | **Variance (UHP)** | **Variance (HP)** | **Percentage Risk Minimization (%)** |
| **Insample Forecasting** | | | | |
| **Mean Specification : Intercept** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.21 | 0.78 | 0.73 | 6.81% |
| 5 Days | 0.76 | 1.53 | 0.85 | 44.36% |
| 10 Days | 0.32 | 1.05 | 0.86 | 18.06% |
| 15 Days | 0.74 | 2.07 | 0.71 | 65.84% |
| 20 Days | 1.43 | 5.42 | 1.64 | 69.81% |
| **Mean Specification : VAR** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.17 | 0.86 | 0.82 | 4.70% |
| 5 Days | 0.24 | 1.84 | 1.7 | 7.45% |
| 10 Days | 0.4 | 1.25 | 0.92 | 26.35% |
| 15 Days | 0.42 | 1.6 | 1.09 | 31.80% |
| 20 Days | 0.64 | 3.51 | 1.99 | 43.24% |
| **Mean Specification : VECM** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.17 | 0.97 | 0.93 | 4.31% |
| 5 Days | 0.29 | 1.75 | 1.58 | 9.80% |
| 10 Days | 0.38 | 1.17 | 0.9 | 22.92% |
| 15 Days | 0.42 | 1.56 | 1.07 | 30.95% |
| 20 Days | 0.65 | 3.49 | 1.88 | 46.08% |

## Appendix G: Minimum variance measurement results for CCC

| Variance Specification : Constant Correlation Model | | | | |
|---|---|---|---|---|
| | Hedging Ratio Estimation | Variance (UHP) | Variance (HP) | Percentage Risk Minimization |
| **Outsample Forecasting** | | | | |
| **Mean Specification : Intercept** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.84 | 0.25 | 0.18 | 29.37% |
| 5 Days | 0.3 | 0.21 | 0.15 | 29.37% |
| 10 Days | 2.08 | 1.95 | 1.37 | 29.37% |
| 15 Days | 0.16 | 0.34 | 0.24 | 29.37% |
| 20 Days | 0.71 | 4.29 | 3.03 | 29.37% |
| **Mean Specification : VAR** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.65 | 1.24 | 0.79 | 36.66% |
| 5 Days | 0.47 | 1.07 | 0.68 | 36.66% |
| 10 Days | 0.47 | 1 | 0.63 | 36.66% |
| 15 Days | 0.49 | 1.63 | 1.03 | 36.66% |
| 20 Days | 0.46 | 2.41 | 1.53 | 36.66% |
| **Mean Specification : VECM** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.67 | 1.27 | 0.79 | 37.86% |
| 5 Days | 0.48 | 1.06 | 0.66 | 37.86% |
| 10 Days | 0.5 | 1 | 0.62 | 37.86% |
| 15 Days | 0.51 | 1.64 | 1.02 | 37.86% |
| 20 Days | 0.46 | 2.29 | 1.42 | 37.86% |

| Variance Specification : Constant Correlation Model | | | | |
|---|---|---|---|---|
| | **Hedging Ratio Estimation** | **Variance (UHP)** | **Variance (HP)** | **Percentage Risk Minimization** |
| **Insample Forecasting** | | | | |
| **Mean Specification : Intercept** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.84 | 0.24 | 0.17 | 28.53% |
| 5 Days | 0.36 | 0.37 | 0.26 | 28.53% |
| 10 Days | 1.84 | 2.04 | 1.46 | 28.53% |
| 15 Days | 0.17 | 0.37 | 0.27 | 28.53% |
| 20 Days | 0.7 | 4.04 | 2.89 | 28.53% |
| **Mean Specification : VAR** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.65 | 1.22 | 0.79 | 35.66% |
| 5 Days | 0.54 | 2 | 1.29 | 35.66% |
| 10 Days | 0.54 | 1.93 | 1.24 | 35.66% |
| 15 Days | 0.5 | 1.81 | 1.16 | 35.66% |
| 20 Days | 0.51 | 1.87 | 1.2 | 35.66% |
| **Mean Specification : VECM** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.67 | 1.26 | 0.79 | 36.81% |
| 5 Days | 0.54 | 1.93 | 1.22 | 36.81% |
| 10 Days | 0.55 | 1.93 | 1.22 | 36.81% |
| 15 Days | 0.51 | 1.82 | 1.15 | 36.81% |
| 20 Days | 0.51 | 1.84 | 1.16 | 36.81% |

## Appendix H: Minimum variance measurement results for DCC

| Variance Specification : Dynamic Conditional Correlation Model | | | | |
|---|---|---|---|---|
| | **Hedging Ratio Estimation** | **Variance (UHP)** | **Variance (HP)** | **Percentage Risk Minimization** |
| **Outsample Forecasting** | | | | |
| **Mean Specification : Intercept** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.59 | 1.24 | 0.87 | 29.69% |
| 5 Days | 0.4 | 0.97 | 0.68 | 30.47% |
| 10 Days | 0.45 | 1.06 | 0.74 | 30.57% |
| 15 Days | 0.46 | 1.73 | 1.18 | 31.87% |
| 20 Days | 0.58 | 3.41 | 1.95 | 42.79% |
| **Mean Specification : VAR** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.57 | 1.28 | 0.94 | 26.45% |
| 5 Days | 0.39 | 1.18 | 0.88 | 25.52% |
| 10 Days | 0.44 | 1.03 | 0.69 | 33.13% |
| 15 Days | 0.55 | 1.81 | 0.99 | 45.49% |
| 20 Days | 0.56 | 2.65 | 1.18 | 55.69% |
| **Mean Specification : VECM** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.58 | 1.33 | 0.98 | 26.10% |
| 5 Days | 0.43 | 1.15 | 0.81 | 29.71% |
| 10 Days | 0.49 | 1.04 | 0.66 | 36.89% |
| 15 Days | 0.57 | 1.79 | 0.95 | 46.94% |
| 20 Days | 0.54 | 2.43 | 1.08 | 55.66% |

| Variance Specification : Dynamic Conditional Correlation Model | | | | |
|---|---|---|---|---|
| | **Hedging Ratio Estimation** | **Variance (UHP)** | **Variance (HP)** | **Percentage Risk Minimization** |
| **Insample Forecasting** | | | | |
| **Mean Specification : Intercept** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.6 | 1.25 | 0.87 | 30.69% |
| 5 Days | 0.4 | 0.97 | 0.67 | 30.60% |
| 10 Days | 0.46 | 1.08 | 0.74 | 31.01% |
| 15 Days | 0.46 | 1.73 | 1.17 | 32.06% |
| 20 Days | 0.58 | 3.44 | 1.99 | 42.05% |
| **Mean Specification : VAR** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.58 | 1.29 | 0.94 | 27.63% |
| 5 Days | 0.39 | 1.13 | 0.83 | 26.22% |
| 10 Days | 0.45 | 1.04 | 0.69 | 34.02% |
| 15 Days | 0.54 | 1.77 | 0.99 | 43.91% |
| 20 Days | 0.56 | 2.63 | 1.18 | 54.99% |
| **Mean Specification : VECM** | | | | |
| No Of Days Forecast | | | | |
| 1 Day | 0.59 | 1.34 | 0.97 | 27.42% |
| 5 Days | 0.43 | 1.11 | 0.76 | 31.53% |
| 10 Days | 0.5 | 1.05 | 0.65 | 38.02% |
| 15 Days | 0.55 | 1.79 | 0.99 | 44.88% |
| 20 Days | 0.53 | 2.48 | 1.13 | 54.22% |

## Appendix I: ICSS Algorithm Results

| | ICSS(IT) | ICSS(k1) | ICSS(k2) |
|---|---|---|---|
| CPO | 05/11/1996 (220) | 07/10/1996 (199) | |
| | 16/04/1997 (336) | 16/04/1997 (336) | |
| | 19/09/1997 (448) | 19/09/1997 (448) | |
| | 13/10/1997 (464) | 02/01/1998 (523) | |
| | 02/01/1998 (523) | 10/03/1998 (570) | |
| | 10/03/1998 (570) | 10/05/1999 (875) | |
| | 04/08/1998 (675) | 02/08/1999 (934) | |
| | 31/08/1998 (694) | 08/09/1999 (961) | |
| | 10/09/1998 (702) | 01/10/2000 (1239) | |
| | 27/01/1999 (801) | 05/08/2002 (1719) | |
| | 26/07/1999 (929) | 25/03/2005 (2408) | |
| | 08/09/1999 (961) | 24/10/2005 (2559) | |
| | 01/10/2000 (1239) | | |
| | 14/12/2000 (1292) | | |
| | 26/06/2001 (1430) | | |
| | 11/07/2001 (1441) | | |
| | 17/07/2001 (1445) | | |
| | 15/12/2001 (1532) | | |
| | 01/07/2002 (1694) | | |
| | 03/07/2002 (1696) | | |
| | 05/08/2002 (1719) | | |
| | 07/04/2003 (1894) | | |
| | 19/09/2003 (2013) | | |
| | 21/11/2003 (2058) | | |
| | 01/03/2004 (2129) | | |
| | 09/04/2004 (2158) | | |
| | 13/05/2004 (2182) | | |
| | 04/06/2004 (2198) | | |
| | 25/03/2005 (2408) | | |
| | 24/10/2005 (2559) | | |
| | 30/06/2006 (2738) | | |
| | 02/11/2006 (2827) | | |
| | 30/04/2007 (2954) | | |
| | 03/05/2007 (2957) | | |
| | 24/05/2007 (2972) | | |
| | 20/06/2007 (2991) | | |
| | 18/10/2007 (3077) | | |
| | 22/10/2007 (3079) | | |
| | 10/01/2008 (3137) | | |
| | 28/02/2008 (3172) | | |
| | 02/04/2008 (3196) | | |
| | 18/07/2008 (3273) | | |

| | | | |
|---|---|---|---|
| FCPO | 31/10/1996 (217) | 31/10/1996 (217) | 31/10/1996 (217) |
| | 15/09/1997 (444) | 15/09/1997 (444) | 02/07/2001 (1434) |
| | 20/10/1997 (469) | 20/10/1997 (469) | 02/10/2001 (1500) |
| | 26/12/1997 (518) | 26/12/1997 (518) | 18/03/2008 (3185) |
| | 12/02/1998 (552) | 12/02/1998 (552) | |
| | 08/09/1998 (700) | 08/09/1998 (700) | |
| | 20/01/1999 (796) | 02/07/2001 (1434) | |
| | 01/07/1999 (912) | 16/01/2002 (1576) | |
| | 27/08/1999 (953) | 01/04/2005 (2413) | |
| | 03/10/2000 (1240) | 31/03/2006 (2673) | |
| | 21/03/2001 (1361) | 11/01/2008 (3138) | |
| | 12/06/2001 (1420) | | |
| | 02/10/2001 (1500) | | |
| | 14/12/2001 (1553) | | |
| | 01/04/2005 (2413) | | |
| | 03/10/2005 (2544) | | |
| | 31/03/2006 (2673) | | |
| | 27/10/2006 (2823) | | |
| | 28/02/2008 (3172) | | |
| | 01/04/2008 (3195) | | |
| | 13/05/2008 (3225) | | |
| | 18/07/2008 (3273) | | |

* Position of the observation where the break is identified represents in the brackets.

## Appendix J: BEKK-GARCH and BEKK-GARCH SB persistency estimation results

| | BEKK-GARCH | | | |
|---|---|---|---|---|
| | ***A**** | ***G**** | ***A*+G**** | ***Log Likelihood*** |
| **CPO** | 0.005 | 0.95 | 0.955 | |
| **FCPO** | 0.285 | 0.866 | 1.151 | -10744 |

| | BEKK-GARCH SB | | | |
|---|---|---|---|---|
| | ***A**** | ***G**** | ***A*+G**** | ***Log Likelihood*** |
| **CPO** | 0.15 | 0.93 | 1.08 | |
| **FCPO** | 0.005 | 0.93 | 0.935 | -10752 |

## Appendix K : Unit Root Tests Results

| | ADF Test | PP Test |
|---|---|---|
| | **Level** | **Level** |
| BEKK-GARCH | -6.0629 | -4.8549 |
| | [0.0000] | [0.0000] |
| BEKK-GARCH SB | -9.0297 | -7.3863 |
| | [0.0000] | [0.0000] |

P-values are provided in parentheses for these two tests.