Manera, Matteo; Lanza, Alessandro; McAleer, Michael

Working Paper

Modelling Dynamic Conditional Correlations in WTI Oil Forward and Futures Returns

Nota di Lavoro, No. 72.2004

Provided in Cooperation with:
Fondazione Eni Enrico Mattei (FEEM)

Suggested Citation: Manera, Matteo; Lanza, Alessandro; McAleer, Michael (2004) : Modelling Dynamic Conditional Correlations in WTI Oil Forward and Futures Returns, Nota di Lavoro, No. 72.2004, Fondazione Eni Enrico Mattei (FEEM), Milano

This Version is available at:
http://hdl.handle.net/10419/117949

Terms of use:
Documents in EconStor may be saved and copied for your personal and scholarly purposes.
You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.
If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Standard-Nutzungsbedingungen:
Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.
Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.
Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.
Modelling Dynamic Conditional Correlations in WTI Oil Forward and Futures Returns
Alessandro Lanza, Matteo Manera and Michael McAleer

NOTA DI LAVORO 72.2004

Alessandro Lanza, Eni S.p.A and Fondazione Eni Enrico Mattei
Matteo Manera, Department of Statistics, University of Milan-Bicocca and Fondazione Eni Enrico Mattei
Michael McAleer, School of Economics and Commerce, University of Western Australia

This paper can be downloaded without charge at:
The Fondazione Eni Enrico Mattei Note di Lavoro Series Index:
http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm
Social Science Research Network Electronic Paper Collection:
http://ssrn.com/abstract=XXXXXX

The opinions expressed in this paper do not necessarily reflect the position of Fondazione Eni Enrico Mattei
Modelling Dynamic Conditional Correlations in WTI Oil Forward and Futures Returns

Summary
This paper estimates the dynamic conditional correlations in the returns on WTI oil one-month forward prices, and one-, three-, six-, and twelve-month futures prices, using recently developed multivariate conditional volatility models. The dynamic correlations enable a determination of whether the forward and various futures returns are substitutes or complements, which are crucial for deciding whether or not to hedge against unforeseen circumstances. The models are estimated using daily data on WTI oil forward and futures prices, and their associated returns, from 3 January 1985 to 16 January 2004. At the univariate level, the estimates are statistically significant, with the occasional asymmetric effect in which negative shocks have a greater impact on volatility than positive shocks. In all cases, both the short- and long-run persistence of shocks are statistically significant. Among the five returns, there are ten conditional correlations, with the highest estimate of constant conditional correlation being 0.975 between the volatilities of the three-month and six-month futures returns, and the lowest being 0.656 between the volatilities of the forward and twelve-month futures returns. The dynamic conditional correlations can vary dramatically, being negative in four of ten cases and being close to zero in another five cases. Only in the case of the dynamic volatilities of the three-month and six-month futures returns is the range of variation relatively narrow, namely (0.832, 0.996). Thus, in general, the dynamic volatilities in the returns in the WTI oil forward and future prices can be either independent or interdependent over time.

Keywords: Constant conditional correlations, Dynamic conditional correlations, Multivariate GARCH models, Forward prices and returns, Futures prices and returns, WTI oil prices

JEL Classification: C32, G10, Q40

The authors wish to thank Damiano Brigo, Felix Chan, Umberto Cherubini, Marzio Galeotti, Toshiki Honda, Ryozo Miura, Kazuhiko Ohashi and Peter Thomson for insightful discussion, seminar participants at the Fondazione Eni Enrico Mattei, Catholic University of Milan and University of Milan-Bicocca for useful comments and suggestions, and Margherita Grasso for efficient research assistance. The third author is most grateful for the hospitality of the Fondazione Eni Enrico Mattei, and the financial support of the Australian Research Council. An earlier version of this paper was presented at the 4th International Conference on Financial Engineering and Statistical Finance, Hitotsubashi University, Tokyo, Japan, March 2004.

Address for correspondence:
Matteo Manera
Department of Statistics
University of Milan-Bicocca
Via Bicocca degli Arcimboldi, 8
20126 Milan
Italy
Phone: +39 02 64487319
Fax: +39 02 6473312
E-mail: matteo.manera@unimib.it
1. Introduction

Substantial research has been undertaken on spot, forward and futures markets of both physical and financial commodities. Much of the research on analyzing the connection between spot, forward and futures prices, and their associated returns, has concentrated on the unbiasedness or efficient market hypothesis and, when such prices are non-stationary, on cointegration among these variables. Hypotheses regarding efficient markets are important for understanding optimal decision making in terms of hedging and speculation. They are also crucial for making financial decisions about the optimal allocation of portfolios of assets in terms of their multivariate returns and associated risks.

Little or no research has been undertaken on analyzing the volatilities (or risks) associated with these portfolios of returns at the multivariate level. Shocks to returns can be decomposed into predictable and unpredictable components. There are two predictable components in these shocks to returns, namely the serial correlation in shocks to the conditional mean and the volatility in the conditional variance. These volatilities can vary over time, either conditionally, as in GARCH-type models, or randomly, as in Stochastic Volatility (SV) models. SV models are typically computationally intensive, even at the univariate level. Extensions to multivariate SV models are presently at a relatively early stage of development. On the other hand, univariate and multivariate GARCH models have become widely established in theoretical and empirical finance and financial econometrics. The structural and statistical properties have been fully developed, and the computational requirements are not generally burdensome, except in special circumstances.

In the case of modelling multivariate returns, such as the returns on the forward and futures prices of different maturities in the market for WTI oil, the shocks to returns not only have dynamic interdependence in risks, but also in the conditional correlations. This is an extension of the constant (or static) conditional correlation approach to analyzing multivariate risks associated with portfolios of assets.

The purpose of this paper is to estimate the dynamic conditional correlations in the returns on WTI oil one-month forward prices, and one-, three-, six-, and twelve-month futures prices, using recently developed multivariate conditional volatility models. The dynamic correlations will enable a determination of whether the forward and various futures returns are substitutes or complements,
which are crucial for deciding whether or not to hedge against unforeseen circumstances. The models are estimated using daily data on WTI oil forward and futures prices, and their associated returns, from 3 January 1985 to 16 January 2004. At the univariate level, the estimates are statistically significant, with the occasional asymmetric effect in which negative shocks have a greater impact on volatility than positive shocks. There can be substantial differences among the estimated constant and dynamic conditional correlations. It is found that the dynamic volatilities in the returns in the WTI oil forward and future prices can be either independent or interdependent over time.

The plan of the paper is as follows. Section 2 analyses market efficiency and volatility in the energy market. Alternative multivariate volatility models are discussed in Section 3. The data used in the empirical analysis and the resulting estimates are presented in Section 4. Some concluding remarks are given in Section 5.


The literature on the relationships between spot and futures prices of petroleum products has examined issues such as market efficiency and price discovery, but far less attention has been paid to volatility, as well as correlations in the shocks to volatility, in the spot and futures markets. Given the importance of both aspects for the present paper, this section provides a brief discussion of the relevant literature.

2.1. Market Efficiency Literature

A standard definition of market efficiency is that today’s price of an item contains all the price information about that item. That is, today’s price contains information about people’s expectations about the future. The hypothesis that heating oil futures prices are good predictors of spot prices was tested by Bopp and Sitzer (1987), who found that, even when crude oil prices, inventory levels, weather, and other important variables were accounted for, futures prices still made a significant positive contribution to describing past price changes. Serletis and Banack (1990) used daily data for the spot and two-month futures crude oil prices, and for prices of gasoline and heating oil traded
on the New York Stock Exchange (NYMEX), to test for market efficiency, and found evidence that was consistent with this hypothesis.

Crowder and Hamid (1993) used cointegration analysis to test the simple efficiency hypothesis and the arbitrage condition for crude oil futures. In the price discovery literature, Quan (1992) examined the price discovery process for the crude oil market using monthly data, and found that the futures price did not play an important role in this process. Using daily data for NYMEX closing futures prices, Schwartz and Szakmary (1994) found that futures prices strongly dominated in the price discovery relative to the deliverable spots in all three petroleum markets. Gulen (1999) applied cointegration tests in a series of oil markets with pairwise comparisons on post-1990 data, and concluded that oil markets have grown more unified during the period 1994-1996 as compared with the period 1991-1994. Silvapulle and Moosa (1999) examined the daily spot and futures prices of WTI crude using both linear and non-linear causality testing. They found that linear causality testing revealed that futures prices lead spot prices, whereas non-linear causality testing revealed a bi-directional effect. Xiaowen and Tamvakis (2001) investigated information transmission between the NYMEX and London’s International Petroleum Exchange, and found that NYMEX was a true leader in the crude oil market. Hammoudeh et al. (2003) also investigated information transmission among NYMEX WTI crude prices, NYMEX gasoline prices, NYMEX heating oil prices, and among international gasoline spot markets, including the Rotterdam and Singapore markets, and found the NYMEX gasoline market to be the true leader.

2.2. Volatility and the Energy Market

Day and Lewis (1993) compared the forecasts of crude oil volatility using GARCH(1,1), EGARCH(1,1), implied volatility and historical volatility models, based on daily data from November 1986 to March 1991. Using OLS regressions of realized volatility on out-of sample forecasts, they examined the unbiasedness of the forecasts. The accuracy of out-of sample forecasts was compared using traditional criteria such as the mean forecast error, mean absolute error, and root mean squared error. They also analysed the within-sample information content of implied volatility, by including it as predictor in the GARCH and EGARCH models. It was found that both implied volatilities, as well as the GARCH and EGARCH conditional volatilities, contributed incremental volatility information. The null hypothesis that implied volatilities subsumed all information contained in observed returns was rejected, as was the hypothesis that option prices had
no additional information. This would indicate that a composite forecast based on implied volatility and GARCH estimates would yield superior results as each would contribute unique information that was not contained in the other. However, empirical evidence indicated that the GARCH forecasts and historical volatility did not add substantial explanatory power to forecasts that were based on implied volatilities.

Tests for the accuracy of forecasts based on traditional forecast error criteria also support the conclusion that the implied volatilities alone are sufficient for market professionals to predict short-run volatilities of up to two months. Duffie and Gray (1995) constructed in-sample and out-of-sample forecasts for volatility in the crude oil, heating oil, and natural gas markets over the period May 1988 to July 1992. Forecasts from GARCH(1,1), EGARCH(1,1), bivariate GARCH(1,1), regime switching, implied volatility, and historical volatility predictors were compared with the realized volatility in terms of root mean squared error. They found that implied volatility yielded the best in-sample and out-of-sample forecasts, and that historical volatility forecasts were superior to their GARCH counterparts in the out-of-sample forecasts.

3. Modelling Multivariate Volatility

The purpose of the empirical section is to model the volatility in the returns of one-month WTI forward oil prices, and one-, three-, six-, and twelve-month oil futures prices. The estimated multivariate models are the Constant Conditional Correlation (CCC) Multivariate GARCH model of Bollerslev (1990) and the Dynamic Conditional Correlation (DCC) model of Engle (2002). The specification, as well as the structural and statistical properties, of these models are discussed briefly in this section.

Consider the following specification:

\[ y_t = E(y_t | F_{t-1}) + \epsilon_t, \]  
\[ \epsilon_t = D_\eta \eta_t, \]  

(1)
where \( y_t = (y_{t1}, \ldots, y_{tm})' \), \( \eta_t = (\eta_{t1}, \ldots, \eta_{mt})' \) is a sequence of independently and identically distributed (iid) random vectors, \( F_t \) is the past information available up to time \( t \), \( D_t = \text{diag} \left( h_{t1}^{1/2}, \ldots, h_{mt}^{1/2} \right) \), \( m \) is the total number of oil price returns to be analysed, and \( t = 1, \ldots, n \). Bollerslev (1990) assumed that the conditional variance for each return, \( h_i, i = 1, \ldots, m \), follows a univariate GARCH process, that is,

\[
h_i = \omega_i + \sum_{j=1}^{r} \alpha_{ij} \varepsilon_{i,t-j}^2 + \sum_{j=1}^{s} \beta_{ij} h_{i,t-j}
\]

where \( \alpha_{ij} \) represents the ARCH effects, or the short-run persistence of shocks to return \( i \), and \( \beta_{ij} \) represents the GARCH effects, or the contribution of shocks to return \( i \) to long-run persistence, namely \( \sum_{j=1}^{r} \alpha_{ij} + \sum_{j=1}^{s} \beta_{ij} \).

Although the CCC specification in (2) has a computational advantage over some other multivariate GARCH models, such as the BEKK model of Engle and Kroner (1995), which models conditional covariances, CCC nevertheless assumes independence of the conditional variances across returns and does not accommodate asymmetric behaviour. In order to accommodate the asymmetric impacts of positive and negative shocks, Glosten, Jagannathan and Runkle (1992) proposed the asymmetric GARCH, or GJR, specification for the conditional variance which, for \( r = s = 1 \), is given by:

\[
h_i = \omega_i + \alpha_{ij} \varepsilon_{i,t-1}^2 + \gamma_i I_{i,t-1} \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1}
\]

where

\[
I_{i,t} = \begin{cases} 
0, & \varepsilon_{i,t} \geq 0 \\
1, & \varepsilon_{i,t} < 0 
\end{cases}
\]

is an indicator function to distinguish between positive and negative shocks on conditional volatility.
The parameters of models (1), (2) and (3) are typically obtained by maximum likelihood estimation (MLE) using a joint normal density for $\eta_t$. When $\eta_t$ does not follow a joint (multivariate) normal distribution, the solution to maximizing the likelihood function is defined as the Quasi-MLE (QMLE).

It is important to note that the conditional correlations are assumed to be constant for the CCC model. From equation (1), it follows that $\varepsilon_t \varepsilon_t' = D_t \eta_t \eta_t' D_t', \quad \text{so that} \quad E(\varepsilon_t \varepsilon_t' | F_{t-1}) = \Omega_t = D_t \Gamma D_t'$. The conditional correlation matrix is defined as $\Gamma = D_t^{-1} \Omega_t D_t^{-1}$, where $\Gamma$ has typical constant element $\rho_{ij} = \rho_{ji}$, for $i, j = 1, \ldots, m$ and $t = 1, \ldots, n$.

When $m = r = s = 1$, such that a univariate model is specified, the necessary and sufficient condition for the existence of the second moment of $\varepsilon_t$ in model (2), that is $E(\varepsilon_t^2) < \infty$, is $\alpha_i + \beta_i < 1$. This condition is also sufficient for the QMLE to be consistent and asymptotically normal. For the GJR(1,1) model (3) $\omega_1 > 0$, $\alpha_i + \gamma_i > 0$ and $\beta_i > 0$ are sufficient conditions to ensure that the conditional variance $h_{tt} > 0$. The short-run persistence of positive (respectively, negative) shocks is given by $\alpha_i$ (respectively, $\alpha_i + \gamma_i$). Under the assumption that the conditional shocks $\eta_{tt}$, $t = 1, \ldots, n$, follow a symmetric distribution, the average short-run persistence is $\alpha_i + \gamma_i / 2$, and the average long-run persistence is $\alpha_i + \gamma_i / 2 + \beta_i$. Ling and McAleer (2002a) showed that the necessary and sufficient condition for $E(\varepsilon_t^2) < \infty$ in the GJR(1,1) model is $\alpha_i + \gamma_i / 2 + \beta_i < 1$. McAleer, Chan and Marinova (2002) established the log-moment condition for GJR(1,1), namely $E\left( \log\left( (\alpha_i + \gamma_i (\eta_{tt})) (\eta_{tt})^2 + \beta_i \right) \right) < 0$, and showed that it is sufficient for the consistency and asymptotic normality of the QMLE for GJR(1,1). If the log-moment condition is satisfied, the second moment condition, namely $\alpha_i + \gamma_i / 2 + \beta_i < 1$, is also sufficient for consistency and asymptotic normality of the QMLE for GJR(1,1).

Unless $\eta_t$ is a sequence of iid random vectors, the assumption of constant conditional correlation will not be valid. In order to capture the dynamics of time-varying conditional correlation, $\Gamma_t$, Engle (2002) and Tse and Tsui (2002) proposed the closely related DCC model and the Variable Conditional Correlation (VCC) Multivariate GARCH model, respectively. The DCC model, which is a special case of the VCC model, is given as
\[
\Gamma_t = (1 - \theta_1 - \theta_2) \Gamma + \theta_1 \pi_{t-1} \pi_{t-1}' + \theta_2 \Gamma_{t-1}
\]  

(4)

in which \( \theta_1 \) and \( \theta_2 \) are scalar parameters to capture the effects of previous shocks and previous dynamic conditional correlations on current dynamic conditional correlations.

The purpose of the following empirical section is to investigate the asymmetric and interdependent effects of the conditional volatilities in the returns to the WTI oil forward and futures prices.

4. Data and Empirical Results

The univariate and multivariate GARCH models are estimated using daily data on WTI oil one-month forward price (WFORW) and one- (WFUT1), three- (WFUT3), six- (WFUT6), and twelve-month (WFUT12) futures prices, and their associated returns, for the period 3 January 1985 to 16 January 2004.

Figures 1-3 show the returns to the one-month forward price and the one-, three-, six-, and twelve-month futures prices. It is clear from these graphs that there is substantial clustering in the returns, and hence also in the corresponding volatilities. The returns in all the series are similar with regard to the presence of some extreme observations and the possible outlier corresponding to the first Gulf Crisis in January 1991.

The univariate estimates of the conditional volatilities based on the forward and futures returns are given in Tables 1 and 2. The three entries for each parameter are their respective estimates, asymptotic t-ratios and Bollerslev-Wooldridge (1992) robust t-ratios. The results in Table 1 are used to estimate the CCC model of Bollerslev (1990) and the DCC model of Engle (2002). Both the short- and long-run persistence of shocks are significant for forward and futures returns. The ARCH (GARCH) effect is the largest (smallest) for the twelve-month futures returns. Although the second moment condition is not satisfied for the twelve-month futures price returns, the log-moment condition is always satisfied, so that the QMLE are consistent and asymptotically normal.
The univariate GJR estimates in Table 2 are reasonably similar to the corresponding estimates in Table 1. At the univariate level, the estimates of the asymmetric effect in which negative shocks have a greater impact on volatility than positive shocks are significant only when the asymptotic t-ratios are used. The second moment condition is not satisfied for the forward and twelve-month futures returns, but the log-moment condition is always satisfied, so that the QMLE are consistent and asymptotically normal.

Constant conditional correlations between the volatilities of forward and futures returns using the CCC model based on estimating univariate GARCH(1,1) models for each returns are given in Table 3. For the five returns, there are ten conditional correlations, with the highest estimated constant conditional correlation being 0.975 between the standardized shocks to the volatilities in the three-month and six-month futures returns, and the lowest being 0.656 between the standardized shocks to the volatilities in the forward and twelve-month futures returns. The calculated constant conditional correlations would seem to be consistent with a reasonable expectation that the correlation decreases as the length of the forward contract increases.

Finally, the DCC estimates of the conditional correlations between the volatilities of forward and futures returns based on estimating univariate GARCH(1,1) models for each returns are given in Table 4. Based on the asymptotic standard errors, the estimates of the two DCC parameters are always statistically significant, which makes it clear that the assumption of constant conditional correlation is not supported empirically. The short run persistence of shocks on the dynamic correlations is greatest between the forward returns and the one-month futures returns, followed closely by the forward returns and the three-month futures returns.

The time-varying nature of the conditional correlations is highlighted by the dynamic conditional correlations between the standardized shocks to the forward and futures returns in Figures 4-13. These dynamic correlations vary dramatically, being negative in four of ten cases, close to zero in another three cases, and in the middle range for two other cases. Only in the case of the dynamic correlations between the three-month and six-month futures returns is the range of variation relatively narrow, namely (0.832, 0.996) (see Table 5). Therefore, while the dynamic conditional correlations vary considerably, it is only in one of ten cases that the variations do not lead to an economically meaningful range of variation.
The skewness and kurtosis of the dynamic conditional correlations indicate a strong negatively skewed distribution. As an example, we may consider Figure 4, which gives the DCC estimates between the forward and one-month futures returns. The mean correlation from Table 5 is 0.894, which is very close, but not identical to, the CCC estimate of 0.884. The informational value of the DCC estimate can be evaluated by examining the time series behaviour of the time-varying conditional correlations in Figure 4, as well as the maximum and minimum dynamic levels, as reported in Table 5. The maximum value of 0.998 means that, on the corresponding day, forward and one-month futures returns would have the same risk, so that taking a position in the forward or futures market would be equally risky for a one-month horizon. However, if we consider the minimum dynamic conditional correlation of -0.291, we could conclude that shocks to the conditional volatilities would not be perfect substitutes in terms of risk. In general, the dynamic volatilities in the returns to the WTI oil forward and future prices can be either independent or interdependent over time.

5. Conclusion

Substantial research has been undertaken on the spot, forward and futures markets for both physical and financial commodities. Much of the research on analyzing the relationship between spot, forward and futures prices, and their associated returns, has concentrated on the unbiasedness or efficient market hypothesis and, when such prices are non-stationary, on cointegration among these variables.

Hypotheses regarding efficient markets are important for understanding optimal decision making in terms of hedging and speculation. They are also crucial for making financial decisions about the optimal allocation of portfolios of assets in terms of their multivariate returns and the associated risks.

However, little or no research has been undertaken on analyzing the volatilities (or risks) associated with these portfolios of returns at the multivariate level. Shocks to returns can be decomposed into predictable and unpredictable components. There are two predictable components in these shocks to returns, namely the serial correlation in shocks to the conditional mean and the volatility in the conditional variance. These volatilities can vary over time, as in univariate and multivariate...
GARCH models, which have become widely established in theoretical and empirical finance and financial econometrics.

In the case of modelling multivariate returns, such as the returns on the forward and futures prices of different maturities in the market for WTI oil, the shocks to returns may not only have dynamic interdependence in risks, but also in the conditional correlations. This is an extension of the constant (or static) conditional correlation approach to analyzing multivariate risks associated with portfolios of assets.

In this paper we estimated the dynamic conditional correlations in the returns on WTI oil one-month forward prices, and one-, three-, six-, and twelve-month futures prices, using recently developed multivariate conditional volatility and conditional correlation models. The dynamic correlations enabled a determination of whether the shocks to the volatilities in the forward and futures returns of various maturities were substitutes or complements. Such empirical estimates are crucial for deciding whether or not to hedge against unforeseen circumstances.

The univariate and multivariate GARCH models were estimated using daily data on WTI oil one-month forward prices and one-, three-, six, and twelve-month futures prices, and their associated returns, for the period 3 January 1985 to 16 January 2004.

The univariate estimates of the conditional volatilities based on the forward and futures returns were statistically significant, and were used to estimate the CCC model of Bollerslev (1990) and the DCC model of Engle (2002). Although the second moment condition was not satisfied for the twelve-month futures price returns, the log-moment condition was always satisfied, so that the QMLE were always consistent and asymptotically normal.

An asymmetric model based on the univariate GJR model gave estimates that were reasonably similar to the corresponding symmetric estimates. The estimates of the asymmetric effect, in which negative shocks have a greater impact on volatility to positive shocks, were significant based on the asymptotic t-ratios. The second moment condition was not satisfied for the forward and the twelve-month futures returns, but the log-moment condition was always satisfied, so that the QMLE were always consistent and asymptotically normal.
Constant conditional correlations between the volatilities of forward and futures returns were estimated using the CCC model based on estimating univariate GARCH(1,1) models. Among the five returns, there were ten conditional correlations, with the highest estimated constant conditional correlation being 0.975 between the standardized shocks to the volatilities in the three-month and six-month futures returns, and the lowest being 0.656 between the standardized shocks to the volatilities in the forward and twelve-month futures returns.

Based on the asymptotic standard errors, the DCC estimates of the conditional correlations between the volatilities of forward and futures returns based on estimating univariate GARCH(1,1) models for each returns were always statistically significant. This result made it clear that the assumption of constant conditional correlation was not supported empirically. This was highlighted by the dynamic conditional correlations between the forward and futures returns, which varied dramatically. Moreover, the skewness and kurtosis of the dynamic conditional correlation indicated a strong negatively skewed distribution. Only in the case of the dynamic volatilities of the three-month and six-month futures returns was the range of variation relatively narrow. In general, the dynamic volatilities in the returns in the WTI oil forward and future prices could be either independent or interdependent over time.

Future research includes a more detailed examination of the design of an optimal hedging strategy based on estimating a wider range of models yielding dynamic conditional correlations.
References


Ling, S. and M. McAleer (2002b), "Necessary and sufficient moment conditions for the GARCH(r,s) and asymmetric power GARCH(r,s) models", Econometric Theory, 18, 722-729.


Figure 1: Returns to Forward Prices for WTI, 3 January 1985 – 16 January 2004
Figure 2: Returns to One- and Three-month Futures Prices for WTI, 3 January 1985 – 16 January 2004

---

**WFUT1**

---

**WFUT3**
Figure 3: Returns to Six- and Twelve-month Futures Prices for WTI, 3 January 1985 – 16 January 2004
Figure 4: DCC between Forward and One-month Futures Returns

Figure 5: DCC between Forward and Three-month Futures Returns
Figure 6: DCC between Forward and Six-month Futures Returns

Figure 7: DCC between Forward and Twelve-month Futures Returns
Figure 8: DCC between One- and Three-month Futures Returns

Figure 9: DCC between One- and Six-month Futures Returns
Figure 12: DCC between Three- and Twelve-month Futures Returns

Figure 13: DCC between Six- and Twelve-month Futures Returns
Table 1: Univariate AR(1)-GARCH(1,1) Estimates

<table>
<thead>
<tr>
<th>Returns</th>
<th>ω</th>
<th>α</th>
<th>β</th>
<th>Log-moment</th>
<th>Second moment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.29E-06</td>
<td>0.114</td>
<td>0.890</td>
<td>-0.009</td>
<td>0.994</td>
</tr>
<tr>
<td></td>
<td>6.259</td>
<td>24.619</td>
<td>180.481</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.898</td>
<td>6.235</td>
<td>67.277</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFUT1</td>
<td>5.04E-06</td>
<td>0.102</td>
<td>0.897</td>
<td>-0.016</td>
<td>0.999</td>
</tr>
<tr>
<td></td>
<td>7.406</td>
<td>22.959</td>
<td>185.918</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.978</td>
<td>6.726</td>
<td>76.461</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFUT3</td>
<td>2.52E-06</td>
<td>0.078</td>
<td>0.919</td>
<td>-0.012</td>
<td>0.997</td>
</tr>
<tr>
<td></td>
<td>7.291</td>
<td>17.066</td>
<td>206.711</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.685</td>
<td>7.871</td>
<td>103.907</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFUT6</td>
<td>3.13E-06</td>
<td>0.090</td>
<td>0.901</td>
<td>-0.020</td>
<td>0.992</td>
</tr>
<tr>
<td></td>
<td>8.693</td>
<td>19.994</td>
<td>177.192</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.858</td>
<td>6.699</td>
<td>75.440</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFUT12</td>
<td>4.82E-08</td>
<td>0.197</td>
<td>0.853</td>
<td>-0.004</td>
<td>1.050</td>
</tr>
<tr>
<td></td>
<td>16.291</td>
<td>55.153</td>
<td>631.711</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17.763</td>
<td>6.814</td>
<td>50.820</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The three entries for each parameter are their respective estimates, asymptotic t-ratios and Bollerslev-Wooldridge (1992) robust t-ratios.

Table 2: Univariate AR(1)-GJR(1,1) Estimates

<table>
<thead>
<tr>
<th>Returns</th>
<th>ω</th>
<th>α</th>
<th>γ</th>
<th>β</th>
<th>α+1/2γ</th>
<th>Log-moment</th>
<th>Second moment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.24E-06</td>
<td>0.134</td>
<td>-0.042</td>
<td>0.892</td>
<td>0.113</td>
<td>-0.014</td>
<td>1.005</td>
</tr>
<tr>
<td></td>
<td>6.246</td>
<td>23.651</td>
<td>-6.211</td>
<td>187.561</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.836</td>
<td>3.992</td>
<td>-1.194</td>
<td>65.007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFUT1</td>
<td>5.11E-06</td>
<td>0.111</td>
<td>-0.016</td>
<td>0.896</td>
<td>0.103</td>
<td>-0.016</td>
<td>0.999</td>
</tr>
<tr>
<td></td>
<td>7.390</td>
<td>20.421</td>
<td>-2.462</td>
<td>184.325</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.010</td>
<td>4.191</td>
<td>-0.524</td>
<td>73.317</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFUT3</td>
<td>2.26E-06</td>
<td>0.066</td>
<td>0.016</td>
<td>0.924</td>
<td>0.073</td>
<td>-0.011</td>
<td>0.997</td>
</tr>
<tr>
<td></td>
<td>6.694</td>
<td>10.917</td>
<td>2.271</td>
<td>214.241</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.435</td>
<td>4.550</td>
<td>0.819</td>
<td>110.516</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFUT6</td>
<td>2.76E-06</td>
<td>0.075</td>
<td>0.019</td>
<td>0.908</td>
<td>0.084</td>
<td>-0.018</td>
<td>0.993</td>
</tr>
<tr>
<td></td>
<td>7.965</td>
<td>12.748</td>
<td>2.691</td>
<td>182.992</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.631</td>
<td>4.188</td>
<td>0.830</td>
<td>82.079</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFUT12</td>
<td>4.36E-08</td>
<td>0.177</td>
<td>0.025</td>
<td>0.857</td>
<td>0.189</td>
<td>-0.003</td>
<td>1.046</td>
</tr>
<tr>
<td></td>
<td>14.717</td>
<td>32.343</td>
<td>3.534</td>
<td>610.328</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.824</td>
<td>3.920</td>
<td>0.352</td>
<td>53.780</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The three entries for each parameter are their respective estimates, asymptotic t-ratios and Bollerslev-Wooldridge (1992) robust t-ratios.
Table 3: CCC Estimates based on GARCH(1,1)

<table>
<thead>
<tr>
<th>Returns</th>
<th>WFORW</th>
<th>WFUT1</th>
<th>WFUT3</th>
<th>WFUT6</th>
<th>WFUT12</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFORW</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFUT1</td>
<td>0.884</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFUT3</td>
<td>0.855</td>
<td>0.921</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WFUT6</td>
<td>0.818</td>
<td>0.871</td>
<td>0.975</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>WFUT12</td>
<td>0.656</td>
<td>0.686</td>
<td>0.787</td>
<td>0.839</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Table 4: DCC Estimates based on GARCH(1,1)

<table>
<thead>
<tr>
<th>Returns</th>
<th>$\theta_1$</th>
<th>$\theta_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFORW, WFUT1</td>
<td>0.218</td>
<td>0.506</td>
</tr>
<tr>
<td></td>
<td>17.157</td>
<td>27.882</td>
</tr>
<tr>
<td>WFORW, WFUT3</td>
<td>0.188</td>
<td>0.746</td>
</tr>
<tr>
<td></td>
<td>5.671</td>
<td>12.972</td>
</tr>
<tr>
<td>WFORW, WFUT6</td>
<td>0.097</td>
<td>0.869</td>
</tr>
<tr>
<td></td>
<td>9.277</td>
<td>56.258</td>
</tr>
<tr>
<td>WFORW, WFUT12</td>
<td>0.059</td>
<td>0.934</td>
</tr>
<tr>
<td></td>
<td>7.103</td>
<td>94.473</td>
</tr>
<tr>
<td>WFUT1, WFUT3</td>
<td>0.078</td>
<td>0.911</td>
</tr>
<tr>
<td></td>
<td>11.160</td>
<td>112.651</td>
</tr>
<tr>
<td>WFUT1, WFUT6</td>
<td>0.070</td>
<td>0.916</td>
</tr>
<tr>
<td></td>
<td>11.671</td>
<td>124.294</td>
</tr>
<tr>
<td>WFUT1, WFUT12</td>
<td>0.046</td>
<td>0.953</td>
</tr>
<tr>
<td></td>
<td>9.175</td>
<td>179.445</td>
</tr>
<tr>
<td>WFUT3, WFUT6</td>
<td>0.049</td>
<td>0.945</td>
</tr>
<tr>
<td></td>
<td>9.505</td>
<td>151.155</td>
</tr>
<tr>
<td>WFUT3, WFUT12</td>
<td>0.051</td>
<td>0.948</td>
</tr>
<tr>
<td></td>
<td>91.826</td>
<td>4222.739</td>
</tr>
<tr>
<td>WFUT6, WFUT12</td>
<td>0.055</td>
<td>0.944</td>
</tr>
<tr>
<td></td>
<td>13.340</td>
<td>226.657</td>
</tr>
</tbody>
</table>

Notes: The model is $\Gamma_\tau = (1-\theta_1-\theta_2)\Gamma + \theta_1\Sigma_{\tau-1} + \theta_2\Gamma_{\tau-1}$. The two entries for each parameter are their respective estimates and asymptotic t-ratios.
Table 5: Descriptive Statistics for Dynamic Conditional Correlations

<table>
<thead>
<tr>
<th>Returns</th>
<th>Mean</th>
<th>Min.</th>
<th>Max.</th>
<th>S.D.</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFORW, WFUT1</td>
<td>0.894</td>
<td>-0.291</td>
<td>0.998</td>
<td>0.085</td>
<td>-5.181</td>
<td>40.842</td>
</tr>
<tr>
<td>WFORW, WFUT3</td>
<td>0.857</td>
<td>-0.155</td>
<td>0.994</td>
<td>0.112</td>
<td>-3.015</td>
<td>15.776</td>
</tr>
<tr>
<td>WFORW, WFUT6</td>
<td>0.818</td>
<td>0.111</td>
<td>0.985</td>
<td>0.107</td>
<td>-1.954</td>
<td>8.281</td>
</tr>
<tr>
<td>WFORW, WFUT12</td>
<td>0.689</td>
<td>-0.013</td>
<td>0.960</td>
<td>0.177</td>
<td>-0.971</td>
<td>3.277</td>
</tr>
<tr>
<td>WFUT1, WFUT3</td>
<td>0.922</td>
<td>0.403</td>
<td>0.994</td>
<td>0.062</td>
<td>-2.924</td>
<td>16.126</td>
</tr>
<tr>
<td>WFUT1, WFUT6</td>
<td>0.869</td>
<td>0.324</td>
<td>0.988</td>
<td>0.088</td>
<td>-2.274</td>
<td>10.046</td>
</tr>
<tr>
<td>WFUT1, WFUT12</td>
<td>0.715</td>
<td>-0.133</td>
<td>0.969</td>
<td>0.213</td>
<td>-1.472</td>
<td>4.560</td>
</tr>
<tr>
<td>WFUT3, WFUT6</td>
<td>0.974</td>
<td>0.832</td>
<td>0.996</td>
<td>0.019</td>
<td>-2.411</td>
<td>10.800</td>
</tr>
<tr>
<td>WFUT3, WFUT12</td>
<td>0.817</td>
<td>0.016</td>
<td>0.980</td>
<td>0.199</td>
<td>-2.183</td>
<td>7.012</td>
</tr>
<tr>
<td>WFUT6, WFUT12</td>
<td>0.873</td>
<td>0.051</td>
<td>0.993</td>
<td>0.212</td>
<td>-2.421</td>
<td>7.626</td>
</tr>
</tbody>
</table>
NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI
Fondazione Eni Enrico Mattei Working Paper Series

Our Note di Lavoro are available on the Internet at the following addresses:
http://www.feem.it/Feem/Pub/Publications/WPapers/default.html

NOTE DI LAVORO PUBLISHED IN 2003

PRIV 2.2003 Ibolya SCHINDELE: Theory of Privatization in Eastern Europe: Literature Review
PRIV 3.2003 Wietze LISE, Claudia KEMFERT and Richard S.J. TOL: Strategic Action in the Liberalised German Electricity Market
KNOW 5.2003 Reyer GERLAGH: Induced Technological Change under Technological Competition
ETA 6.2003 Efrem CASTELNUOVO: Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model
SIEV 7.2003 Anna ALBERINI, Alberto LONGO, Stefania TONIN, Francesco TROMBETTA and Margherita TURVANI: The Role of Liability, Regulation and Economic Incentives in Brownfield Remediation and Redevelopment: Evidence from Surveys of Developers
NRM 8.2003 Elissaios PAPYRAXIS and Reyer GERLAGH: Natural Resources: A Blessing or a Curse?
CLIM 9.2003 A. CAPARRÓS, J.-C. PEREAU and T. TAZDAÏT: North-South Climate Change Negotiations: a Sequential Game with Asymmetric Information
KNOW 10.2003 Giorgio BRUNELLO and Daniele CHECCHI: School Quality and Family Background in Italy
CLIM 11.2003 Efrem CASTELNUOVO and Marzio GALEOTTI: Learning By Doing vs Learning By Researching in a Model of Climate Change Policy Analysis
KNOW 12.2003 Carole MAIGNAN, Gianmarco OTTAVIANO and Dino PINELLI (eds.): Economic Growth, Innovation, Cultural Diversity: What are we all talking about? A Critical survey of the state-of-the-art
KNOW 14.2003 Maddy JANSSENS and Chris STEYAERT (lix): Theories of Diversity within Organisation Studies: Debates and Future Trajectories
KNOW 15.2003 Tuzin BAYCAN LEVENT, Enno MASUREL and Peter NIJKAMP (lix): Diversity in Entrepreneurship: Ethnic and Female Roles in Urban Economic Life
KNOW 16.2003 Alexandra BITUSIKOVA (lix): Post-Communist City on its Way from Grey to Colourful: The Case Study from Slovakia
KNOW 17.2003 Billy E. VAUGHN and Katarina MLEKOV (lix): A Stage Model of Developing an Inclusive Community
KNOW 18.2003 Selma van LONDON and Arie de RUIJTER (lix): Managing Diversity in a Globalizing World
PRIV 20.2003 Giacomo CALZOLARI and Alessandro PAVAN (lix): Monopoly with Resale
PRIV 22.2003 Marco LiCalzi and Alessandro PAVAN (lix): Tilting the Supply Schedule to Enhance Competition in Uniform-Price Auctions
PRIV 23.2003 David ETTINGER (lix): Bidding among Friends and Enemies
PRIV 24.2003 Hannu VARTIAINEN (lix): Auction Design without Commitment
PRIV 26.2003 Christine A. PARLOUR and Uday RAJAN (lix): Rationing in IPOs
PRIV 27.2003 Kjell G. NYBORG and Ilya A. STREBULAEV (lix): Multiple Unit Auctions and Short Squeezes
PRIV 28.2003 Anders LUNANDER and Jan-Eric NILSSON (lix): Taking the Lab to the Field: Experimental Tests of Alternative Mechanisms to Procure Multiple Contracts
PRIV 30.2003 Emiel MAASLAND and Sander ONDERSTAL (lix): Auctions with Financial Externalities
ETA 31.2003 Michael FINUS and Bianca RUNDHAGEN: A Non-cooperative Foundation of Core-Stability in Positive Externality NTU-Coalition Games
KNOW 32.2003 Michele MORETTO: Competition and Irreversible Investments under Uncertainty
PRIV 33.2003 Philippe QUIRION: Relative Quotas: Correct Answer to Uncertainty or Case of Regulatory Capture?
KNOW 34.2003 Giuseppe MEDA, Claudio PIGA and Donald SIEGEL: On the Relationship between R&D and Productivity: A Treatment Effect Analysis
ETA 35.2003 Alessandra DEL BOCA, Marzio GALEOTTI and Paola ROTA: Non-convexities in the Adjustment of Different Capital Inputs: A Firm-level Investigation
GG 36.2003 Matthieu GLACHANT: Voluntary Agreements under Endogenous Legislative Threats

PRIV 37.2003 Narjess BOUBAKRI, Jean-Claude COSET and Omrane GUEDHAMI: Postprivatization Corporate Governance: the Role of Ownership Structure and Investor Protection

CLIM 38.2003 Rolf GOLOMBEK and Michael HOEL: Climate Policy under Technology Spillovers

KNOW 39.2003 Slim BEN YOUSSEF: Transboundary Pollution, R&D Spillovers and International Trade

CTN 40.2003 Carlo CARRARO and Carmen MARCHIORI: Endogenous Strategic Issue Linkage in International Negotiations


KNOW 42.2003 Tino GOESCHL and Timothy SWANSON: On Biology and Technology: The Economics of Managing Biotechnologies


CLIM 44.2003 Katrin MILLOCK and Céline NAUGES: The French Tax on Air Pollution: Some Preliminary Results on its Effectiveness

PRIV 45.2003 Bernardino BORTOLOTTI and Paolo PINOTTI: The Political Economy of Privatization


ETA 47.2003 Jens HORBACH: Employment and Innovations in the Environmental Sector: Determinants and Econometrical Results for Germany

CLIM 48.2003 Lori SNYDER, Nolan MILLER and Robert STAVINS: The Effects of Environmental Regulation on Technology Diffusion: The Case of Chlorine Manufacturing

CLIM 49.2003 Lori SNYDER, Robert STAVINS and Alexander F. WAGNER: Private Options to Use Public Goods: Exploiting Revealed Preferences to Estimate Environmental Benefits

CTN 50.2003 László A. KÖCZY and Luc LAUWERS (lxii): The Minimal Dominant Set is a Non-Empty Core-Extension

CTN 51.2003 Matthew O. JACKSON (lxii): Allocation Rules for Network Games

CTN 52.2003 Ana MAULEON and Vincent VANNETELBOSCH (lxii): Farsightedness and Cautiousness in Coalition Formation


CTN 54.2003 Matthew HAAG and Roger LAGUNOFF (lxii): On the Size and Structure of Group Cooperation

CTN 55.2003 Taiji FURUSAWA and Hideo KONISHI (lxii): Free Trade Networks

CTN 56.2003 Halis Murat YILDIZ (lxii): National Versus International Mergers and Trade Liberalization

CTN 57.2003 Santiago RUBIO and Alistair ULPH (lxii): An Infinite-Horizon Model of Dynamic Membership of International Environmental Agreements

KNOW 58.2003 Carole MAIGNAN, Dino PINELLI and Gianmarco I.P. OTTAVIANO: ICT, Clusters and Regional Cohesion: A Summary of Theoretical and Empirical Research

KNOW 59.2003 Giorgio BELLETTINI and Gianmarco I.P. OTTAVIANO: Special Interests and Technological Change

ETA 60.2003 Ronnie SCHÖB: The Double Dividend Hypothesis of Environmental Taxes: A Survey

CLIM 61.2003 Michael FINUS, Ekko van IERLAND and Robert DELLINK: Stability of Climate Coalitions in a Cartel Formation Game


SIEV 63.2003 Alberto PETRUCCI: Taxing Land Rent in an Open Economy

CLIM 64.2003 Joseph E. ALDY, Scott BARRETT and Robert N. STAVINS: Thirteen Plus One: A Comparison of Global Climate Policy Architectures

SIEV 65.2003 Edi DEFRANCESCO: The Beginning of Organic Fish Farming in Italy

SIEV 66.2003 Klaus CONRAD: Price Competition and Product Differentiation when Consumers Care for the Environment

SIEV 67.2003 Paolo A.L.D. NUNES, Luca ROSSETTO, Arianne DE BLAEIJ: Revealed Preferences to Estimate Environmental Benefits

CLIM 68.2003 Hongyi ZHANG: Open Trade with the U.S. Without Compromising Canada’s Ability to Comply with its Kyoto Target

KNOW 69.2003 David FRANTZ (lxii): Lorenzo Market between Diversity and Mutation

KNOW 70.2003 Ercole SORI (lxii): Mapping Diversity in Social History

KNOW 71.2003 Liljana DERU SIMIC (lxii): What is Specific about Art/Cultural Projects?

KNOW 72.2003 Natalya V. TARANOVA (lxii): The Role of the City in Fostering Intergroup Communication in a Multicultural Environment: Saint-Petersburg’s Case

KNOW 73.2003 Kristine CRANE (lxii): The City as an Arena for the Expression of Multiple Identities in the Age of Globalisation and Migration

KNOW 74.2003 Kazuma MATOBA (lxii): Global Dialogue- Transformation through Transcultural Communication

KNOW 75.2003 Catarina REIS OLIVEIRA (lxii): Immigrants’ Entrepreneurial Opportunities: The Case of the Chinese in Portugal

KNOW 76.2003 Sandra WALLMAN (lxii): The Diversity of Diversity - towards a typology of urban systems

KNOW 77.2003 Richard PEARCE (lxii): A Biologist’s View of Individual Cultural Identity for the Study of Cities

KNOW 78.2003 Vincent MERK (lxii): Communication Across Cultures: from Cultural Awareness to Reconciliation of the Dilemmas

KNOW 79.2003 Giorgio BELLETTINI, Carlotta BERTI CERONI and Gianmarco I.P. OTTAVIANO: Child Labor and Resistance to Change

ETA 80.2003 Michele MORETTO, Paolo M. PANTEGHINI and Carlo SCARPA: Investment Size and Firm’s Value under Profit Sharing Regulation
One Thousand Working Papers
NOTE DI LAVORO PUBLISHED IN 2004

IEM 1.2004 Anil MARKANDYA, Suzette PEDROSO and Alexander GOLUB: Empirical Analysis of National Income and So2 Emissions in Selected European Countries

ETA 2.2004 Masahisa FUJITA and Shlomo WEBER: Strategic Immigration Policies and Welfare in Heterogeneous Countries

PRA 3.2004 Adolfo DI CARLUCCIO, Giovanni FERRI, Cecilia FRALE and Ottavio RICCHI: Do Privatizations Boost Household Shareholding? Evidence from Italy

ETA 4.2004 Victor GINSBURGH and Shlomo WEBER: Languages Disenfranchisement in the European Union


PRA 7.2004 Sandro BRUSCO, Giuseppe LOPOMO and S. FISANATHAN (Ivx): Merger Mechanisms

PRA 8.2004 Wolfgang AUSSENGANG, Pegaret PICHLER and Alex STOMPER (Ivx): IPO Pricing with Bookbuilding, and a When-Issued Market

PRA 9.2004 Pegaret PICHLER and Alex STOMPER (Ivx): Primary Market Design: Direct Mechanisms and Markets


PRA 11.2004 Bjarnie BRENDSTRUP and Harry J. PAARSCH (Ivx): Nonparametric Identification and Estimation of Multi-Unit, Sequential, Oral, Ascending-Price Auctions With Asymmetric Bidders

PRA 12.2004 Ohad KADAN (Ivx): Equilibrium in the Two Player, k-Doubling Auction with Affiliated Private Values

PRA 13.2004 Maarten C.W. JANSSEN (Ivx): Auctions as Coordination Devices

PRA 14.2004 Gadi FIBICH, Arieh GAVIOUS and Aner SELA (Ivx): All-Pay Auctions with Weakly Risk-Averse Buyers

PRA 15.2004 Orly SADE, Charles SCHNITZLEIN and Jaime F. ZENDER (Ivx): Competition and Cooperation in Divisible Good Auctions: An Experimental Examination

PRA 16.2004 Maria STRYSZOWSKA (Ivx): Late and Multiple Bidding in Competing Second Price Internet Auctions

CCMP 17.2004 Silon Ben YOUSSEF: R&D in Cleaner Technology and International Trade

NRM 18.2004 Angelo ANTOCCI, Simone BORGHESI and Paolo RUSSU (Ivx): Biodiversity and Economic Growth: Stabilization Versus Preservation of the Ecological Dynamics

SIEV 19.2004 Anna ALBERINI, Paolo ROSATO, Alberto LONGO and Valentina ZANATTA: Information and Willingness to Pay in a Contingent Valuation Study: The Value of S. Erasmo in the Lagoon of Venice


NRM 21.2004 Jacqueline M. HAMILTON (Ivx): Climate and the Destination Choice of German Tourists


NRM 23.2004 Pius ODUNGA and Henk FOLMER (Ivx): Profiling Tourists for Balanced Utilization of Tourism-Based Resources in Kenya


NRM 26.2004 Juan Luis EUGENIO-MARTÍN, Noelia MARTÍN MORALES and Riccardo SCARPA (Ivx): Tourism and Economic Growth in Latin American Countries: A Panel Data Approach

NRM 27.2004 Raúl Hernández MARTÍN (Ivx): Impact of Tourism Consumption on GDP, The Role of Imports


NRM 29.2004 Marian WEBER (Ivx): Assessing the Effectiveness of Tradable Landuse Rights for Biodiversity Conservation: an Application to Canada’s Boreal Mixedwood Forest

NRM 30.2004 Honou ODINGA and Henk FOLMER (Ivx): Profiling Tourists for Balanced Utilization of Tourism-Based Resources in Kenya


CTN 33.2004 Wilson PEREZ: Divide and Conquer: Noisy Communication in Networks, Power, and Wealth Distribution


ETA 39.2004 Alberto CAVALIERE: Price Competition with Information Disparities in a Vertically Differentiated Duopoly

PRA 40.2004 Andrea BIGNO and Stef PROOST: The Opening of the European Electricity Market and Environmental Policy: Does the Degree of Competition Matter?

CCMP 41.2004 Micheal FINUS (Ivx): International Cooperation to Resolve International Pollution Problems
### 2003 SERIES

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Editor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLIM</td>
<td>Climate Change Modelling and Policy</td>
<td>Marzio Galeotti</td>
</tr>
<tr>
<td>GG</td>
<td>Global Governance</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td>SIEV</td>
<td>Sustainability Indicators and Environmental Valuation</td>
<td>Anna Alberini</td>
</tr>
<tr>
<td>NRM</td>
<td>Natural Resources Management</td>
<td>Carlo Giupponi</td>
</tr>
<tr>
<td>KNOW</td>
<td>Knowledge, Technology, Human Capital</td>
<td>Gianmarco Ottaviano</td>
</tr>
<tr>
<td>IEM</td>
<td>International Energy Markets</td>
<td>Anil Markandya</td>
</tr>
<tr>
<td>CSRM</td>
<td>Corporate Social Responsibility and Management</td>
<td>Sabina Ratti</td>
</tr>
<tr>
<td>PRIV</td>
<td>Privatisation, Regulation, Antitrust</td>
<td>Bernardo Bortolotti</td>
</tr>
<tr>
<td>ETA</td>
<td>Economic Theory and Applications</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td>CTN</td>
<td>Coalition Theory Network</td>
<td></td>
</tr>
</tbody>
</table>

### 2004 SERIES

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Editor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCMP</td>
<td>Climate Change Modelling and Policy</td>
<td>Marzio Galeotti</td>
</tr>
<tr>
<td>GG</td>
<td>Global Governance</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td>SIEV</td>
<td>Sustainability Indicators and Environmental Valuation</td>
<td>Anna Alberini</td>
</tr>
<tr>
<td>NRM</td>
<td>Natural Resources Management</td>
<td>Carlo Giupponi</td>
</tr>
<tr>
<td>KTHC</td>
<td>Knowledge, Technology, Human Capital</td>
<td>Gianmarco Ottaviano</td>
</tr>
<tr>
<td>IEM</td>
<td>International Energy Markets</td>
<td>Anil Markandya</td>
</tr>
<tr>
<td>CSRM</td>
<td>Corporate Social Responsibility and Management</td>
<td>Sabina Ratti</td>
</tr>
<tr>
<td>PRIV</td>
<td>Privatisation, Regulation, Antitrust</td>
<td>Bernardo Bortolotti</td>
</tr>
<tr>
<td>ETA</td>
<td>Economic Theory and Applications</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td>CTN</td>
<td>Coalition Theory Network</td>
<td></td>
</tr>
</tbody>
</table>