Marc Gronwald [1], Janina Ketterer[2], Stefan Trück[3]

THE DEPENDENCE STRUCTURE BETWEEN CARBON EMISSION ALLOWANCES AND FINANCIAL MARKETS – A COPULA ANALYSIS

[1]Ifo Institut, Germany, +49(0)89 9224-1400, gronwald@ifo.de
[2]Ifo Institut, Germany, +49(0)89 9224-1400, ketterer@ifo.de
[3] Macquarie University, Australia, +61 (0) 2 9850-8483,strueck@efs.mq.edu.au

OVERVIEW

We investigate the relationship between CO2 emission allowance prices and those of various other financial variables and commodities. The literature reports ambiguous results on the dependence structure between emission allowance and commodity or equity markets, see e.g. [1], [3], [8], [9]. Different copulas are applied in order to model the dependence structure between the different return series. As suggested in the literature, the use of correlation as the only measure of dependence can lead to an underestimation of the risk of joint extreme price movements. Further, copula models represent a more flexible method for deriving the nature of dependence and provide an appropriate fit also for the tails of multivariate distributions. We find significant positive correlations between EU emission allowance (EUA) future returns and those of other commodities for the considered markets. Furthermore, we find some dependence between EUA futures and equity or energy index returns. These results contradict earlier studies that report no statistically significant or even negative correlations between returns of emission allowances and other financial variables. Regarding the nature of dependence, we also find some evidence of symmetric tail dependence for most of the considered series what might lean to an underestimation of the risk for a portfolio when an inappropriate model for the dependence is chosen.

METHODS

We apply different copula functions in order to model the complex dependence structure between the return series of carbon emission allowance returns and those of various commodities as well as other financial series. Further we conduct a risk analysis for an exemplary portfolio consisting of equal weights in EUA and Oil Futures contracts as well as a European equity and energy index. As shown in various studies, see e.g. [2], [6], [7] the use of correlation does not appropriately describe the dependence structure between financial assets and could lead to inadequate measurement of the risk. Therefore, we examine the performance of the standard variance-covariance approach in comparison to the application of copulas model, including the Gaussian, Student t, Clayton and Gumbel copula. We estimate the copula parameters using the rank-based measure Kendall's tau to measure the dependence structure when employing Archimedean and elliptical copulas. To evaluate different approaches, we perform goodness-of-fit tests investigating the distance between the estimated and the empirical copula, see e.g. [4], [5]. For the conducted risk analysis of a portfolio containing EUAs, commodities and equities, we use the Value-at-Risk measure that can be considered as industry standard when exploring potential losses or tail risks of a portfolio. To investigate the nature of the dependence through time we further apply a time-varying estimation of the copula parameters for the different series.

RESULTS

We consider the trading period from January-December 2009 and find significant positive correlations between the returns of EUA future contracts and the considered equity indices.

Also the correlations between the return series of EUA futures and electricity, coal and oil futures are positive and significantly different from zero. Our results contradict earlier studies that report no statistically significant or even negative correlations between returns of emission allowances and other financial variables. Regarding the nature of dependence, our results generally support the Student t copula as providing the best fit to the dependence structure between EUA returns and various other commodity and equity return series. For each of the considered series, it yields the smallest distance between the estimated and the actually observed empirical copula and also performs best according to the conducted goodness-of-fit tests. Further, for most of the series also the Gaussian copula outperforms both the Clayton and Gumbel copula that exhibit dependence only in either the lower left or upper right tail. Overall, the results suggest that symmetric copulas seem to be more appropriate to capture the dependence structure between EUA returns and the returns of commodity futures or European equity indices. A risk analysis conducted for a portfolio containing equal weights in EUA and Oil Futures contracts as well as a European equity and energy index indicates that the standard variance-covariance approach underestimates the risk in particular in the extreme tail of the distribution. The standard deviation and in particular the kurtosis of the distribution are higher for the model using the Student t copula for the dependence structure. Investigating the dependence parameters through time we find that overall the dependence between EUA 2010 futures returns and 2010 Gas futures, 2010 Electricity future and Eurostoxx 50 spot returns is slightly decreasing during the considered period.

CONCLUSIONS

We provide a pioneer study on the application of different copula models in order to investigate the dependence structure between EUA future returns and those of other financial assets and commodities during the Kyoto commitment period. We find a significant positive dependence structure between EUA and electricity, coal and oil futures returns as well as between EUA futures and equity and energy index spot returns. We further find some evidence of symmetric tail dependence for most of the return series that is best described by the student t copula. The obvious conclusion that can be drawn from this study is that while EUAs might still be worthwhile for diversifying asset portfolios, they do generally not show negative correlations with commodity or financial markets. An extension of the analysis using data from different trading periods and years would allow conclusions about the stability of the dependence structure between the variables through time. This would yield interesting insights in the general development of this newly established market and its relationship to other financial markets.

REFERENCES

1. Bunn, D., Fezzi, C., 2007. Interaction of european carbon trading and energy prices. Working paper.
2. Cherubini, U., Luciano, E., Vecchiato, W., 2004. Copula Methods in Finance. Wiley Finance Series.
3. Daskalakis, G., Psychoyios, D., Markellos, R., 2009. Modeling CO2 emission allowance prices and derivatives: Evidence from the EEX. Journal of Banking and Finance 33(7).
4. Genest, C., Quessy, J., Remillard, B., 2006. Goodness-of-fit procedures for copula models based on the integral probability transformation. Scandinavian Journal of Statistics 33, 337–366.
5. Genest, C., Remillard, B., Beaudoin, D., 2009. Goodness-of-fit tests for copulas: A review and a power study. Insurance: Mathematics and Economics 44(2), 199–213.
6. Jondeau, E., Rockinger, M., 2006a. The copula-garch model of conditional dependencies: An international stock market application. Journal of International Money and Finance 25, 827–853.
7. Junker, M., Szimayer, A., Wagner, N., 2006. Nonlinear term structure dependence: Copula functions, empirics, and risk implications. Journal of Banking and Finance 30, 1171–1199.
8. Kosobud, R., Stokes, H., Tallarico, C., Scott, B., 2005. Valuing tradable private rights to pollute the public's air. Review of Accounting and Finance (4), 50–71.

9. Nazifi, F., Milunovich, G., 2009. Measuring the impact of carbon allowance trading on energy prices. Working paper, Macquarie University.