THE SNP-DCC MODEL: A NEW METHODOLOGY FOR RISK MANAGEMENT AND FORECASTING

ESTHER B. DEL BRIO
TRINO-MANUEL ÑÍGUEZ
JAVIER PEROTE

FUNDACIÓN DE LAS CAJAS DE AHORROS
DOCUMENTO DE TRABAJO
Nº 532/2010

De conformidad con la base quinta de la convocatoria del Programa de Estímulo a la Investigación, este trabajo ha sido sometido a evaluación externa anónima de especialistas cualificados a fin de contrastar su nivel técnico.

ISSN: 1988-8767

La serie **DOCUMENTOS DE TRABAJO** incluye avances y resultados de investigaciones dentro de los programas de la Fundación de las Cajas de Ahorros.
Las opiniones son responsabilidad de los autores.

THE SNP-DCC MODEL: A NEW METHODOLOGY FOR RISK MANAGEMENT AND FORECASTING

Esther B. Del Brio[+]
Trino-Manuel Ñíguez[*]
Javier Perote

Abstract:

This paper generalizes the Dynamic Conditional Correlation (DCC) model of Engle (2002) to incorporate a flexible non-Gaussian distribution based on Gram-Charlier expansions. The resulting semi-nonparametric (SNP)-DCC model admits a separate estimation of, in a first stage, the individual conditional variances under a Gaussian distribution and, in the second stage, the conditional correlations and the rest of the density parameters, thus overcoming the known "dimensionality curse" of the multivariate volatility models. Furthermore the proposed SNP-DCC model solves the negativity problem inherent to truncated SNP densities providing a parametric structure that may accurately approximate a target heavy-tailed distribution. We test the performance of a SNP-DCC model with respect to the (Gaussian)-DCC through an empirical application of density forecasting for portfolio asset returns data. Our results show that the proposed multivariate model provides a better in-sample fit and forecast of the portfolio returns distribution, being thus useful for financial risk forecasting and evaluation.

JEL classification: C16, G1.

Keywords: Density forecasts; Financial markets; GARCH models; Multivariate time series; Semi-nonparametric methods.

Corresponding author: Javier Perote. Departamento de Economía e Historia Económica,Universidad de Salamanca, Campus Miguel de Unamuno, Facultad de Economía y Empresa (Edificio FES), 37007, Salamanca. Tel: 923-294640 ext. 3512. E-mail: perote@usal.es

[+] Dept. de Administración y Economía de la Empresa. Universidad de Salamanca.

[*] Dept. of Economics and Quantitative Methods. University of Westminster.

Acknowledgements: Financial support from the Spanish Ministry of Science and Technology under Projects SEJ2006-06104/ECON and SEJ2007-66592-C03-03 is gratefully acknowledged.

1. Introduction

The traditional concern of economic forecasting has been focused on producing and evaluating point forecasts. In the last decades, however, an increasing interest for probability and full density forecasting has emerged, especially for macroeconomic and financial variables that exhibit features such as time-varying dependent moments, skewness or excess kurtosis. The forecasting of those variables in terms of intervals (particularly, one-side interval forecasts or Value-at-Risk) or density forecasts has become a topic of major research guided by both the practitioners demands to improve risk measures accuracy, and the development of powerful models for time-varying conditional variances and densities (see e.g. Gouriéroux, 1997, and Jondeau, Poon & Rockinger, 2007) and methods for their evaluation (Clements, 2005). In particular, Christoffersen (1998) provided appropriate techniques for evaluating interval forecasts and Diebold, Gunther & Tay (1998) for density forecasting, the latter methodology being applied during the last decade for forecasting the distribution of varied variables such as expected future inflation in Diebold, Tay & Wallis (1999), option prices in Aït-Sahalia & Lo (1998) or intraday electricity prices in Panagiotelis & Smith (2008) (see Tay & Wallis (2000) for a comprehensive survey on density forecast applications). On the other hand, extensions of density forecasting to the multivariate case are considered by Diebold, Hahn & Tay (1999), Clements & Smith (2000) and, very recently, a strand of literature has focused on proposing density forecasts evaluation methods based on different criteria, such as: the Kullback-Leibler information criterion (Mitchell and Hall (2005) and Bao, Lee & Saltoglu (2007)), weighted likelihood ratio tests (Amisano & Giacomini, 2007), Bayesian approach (Geweke & Amisano, 2008, 2009) and strictly proper scoring rules (Gneiting & Raftery (2007), Gneiting & Ranjan (2008), Diks, Panchenko & van Dijk (2008)); see Mitchell & Wallis (2009) for a review on density forecast evaluation procedures.

In this paper we apply density forecasting techniques in a multivariate framework for testing the performance of a generalization of Engle's (2002) Dynamic Conditional Correlation (DCC hereafter) model which can incorporate not only volatility clustering and time-varying correlations but also all the non-normal stylized features of high frequency financial variables, i.e. skewness, leptokurtosis, multimodality, etc. This new model that we call Semi-nonparametric (SNP hereafter)-DCC specifies a general and flexible multivariate density based on truncated Edgeworth and Gram-Charlier series.[1]

[1] The Cornish and Fisher and the Laguerre expansions are other alternative SNP that might be implemented (see e.g. Cornish and Fisher (1937) and Marumo and Wolff (2007).

These series were initially defined in the seminal papers of Edgeworth (1907) and Charlier (1905) to approximate a probability distribution in terms of its cumulants. Since then, they have been investigated from many perspectives and disciplines, Sargan (1975) being who brought them into econometrics. More recently, that literature has attracted a renewed interest and so we find contributions, in the theoretical field --see, e.g., Nishiyama & Robinson (2000) and Velasco & Robinson (2001)- and in the applied field, with particular emphasis in finance, to deal with the unsolved problem of fitting the heavy-tailed distribution of high-frequency asset returns ---see, e.g., Corrado & Su (1996), Mauleón & Perote (2000) and Verhoeven & McAleer (2004). The latter articles provide empirical evidence on the good in-sample performance of univariate SNP distributions. Nonetheless, the applications of SNP densities require truncation of the Hermite expansion and the resulting density presents then the well-known definition problem of not being positive for all values of the parameters in the parametric space, as firstly highlighted by Barton & Dennis (1952). This problem can be dealt with in different ways, e.g., through parametric restrictions or density reformulations, see the following papers for further details on those procedures: Gallant & Nychka (1987), Gallant & Tauchen (1989), Jondeau & Rockinger (2001), León, Rubio & Serna (2005) and León, Mencía & Sentana (2009).

Focusing on the multivariate context, different methodologies have been proposed to deal with the modeling of the joint distribution of correlated variables, including: (1) multivariate distributions such as, Multivariate Skewed Normal (Azzalini & Dalla Valle, 1996), Multivariate Student's t (Kotz & Nadarajah, 2004), Multivariate Weibull (Malevergne & Sornette, 2004) or Kotz-type distributions (Olcay, 2005), (2) copula methods (see, e.g., Chen, Fan & Tsyrennikov, 2006) and, (3) multivariate GARCH models (see, e.g., Bauwens, Laurent & Rombouts (2005) for a comprehensive review of those models). In particular, the latter methodology includes the following contributions: the vech model (Bollerslev, Engle & Wooldridge, 1988); the Constant Conditional Correlation (CCC) (Bollerslev, 1990); the Factor-ARCH (Engle, Ng & Rothschild, 1990); the BEKK (Engle & Kroner, 1995); the DCC model (Engle (2002) and Engle & Sheppard (2001)); the Time-Varying Correlation (Tse and Tsui, 2002); the Asymmetric DCC (Cappiello, Engle & Sheppard, 2006); or the Dynamic Equicorrelation (DECO) model (Engle & Kelly, 2007). However, up to the knowledge of the authors, much less has been done regarding the modeling of dynamics of the variance-covariance matrix in a SNP framework. Particularly, Perote (2004) and Del Brio, Ñíguez & Perote (2009) have shown that the multivariate SNP modeling renders multivariate flexible densities that provide accurate fits to financial returns series of data, but the densities implemented in those papers assume constant correlations, which although eases their implementation for large portfolios, may be too restrictive. Furthermore, the so-called multivariate Edgeworth-Sargan ES (MES hereafter) distribution introduced by Perote (2004) cannot strictly be considered a probability density function (pdf hereafter) since it is not positive for all values of the parameters in the parametric space, and therefore its applications, e.g. for forecasting, are limited.

Regarding the modeling of multivariate distributions conditional moments, the DCC model (Engle, 2002) was introduced to allow for time-varying correlations, and at the same time deal with the known "curse of dimensionality" of the multivariate context, by means of separate quasi-maximum likelihood estimation (QMLE) of conditional variances, and correlation dynamics. Unfortunately, the DCC model two-step estimation procedure has been so far shown to be theoretically valid only under normality (see Engle & Sheppard (2001) for a detailed discussion on the estimation properties of DCC models). Despite this fact, DCC processes have been implemented in empirical works using the Student's t distribution, i.e., using first stage QMLE of conditional variances followed by second stage MLE of correlation processes and Student's t distribution parameters. Bauwens & Laurent (2005) and Jondeau & Rockinger (2005) showed by means of an empirical application that although the decomposition proposed by Engle (2002) is not formally possible for the Student's t distribution and a one-step approach should be adopted (i.e. joint MLE of conditional variances and covariances processes under the Student's t), the estimation results from both one step and two steps approaches did not differ significantly.

In this article, we jointly analyze the aforementioned problems, namely, the negativity problem inherent to truncated SNP distributions, and the multivariate framework "curse of dimensionality" -Specifically when the model accounts for time-varying correlations-, through a new family of multivariate SNP distributions. That family presents the following features: (i) generality: it encompasses as marginals not only the Gaussian but also the different univariate Edgeworth and Gram-Charlier distributions proposed in the literature, (ii) positiveness: it is positive for all its parameter values in the parametric space, (iii) empirical tractability: it theoretically admits the decomposition proposed by Engle (2002), allowing to obtain consistent MLE (under correct specification), which eases the model implementation, and (iv) it yields a reasonable out-of-sample performance for forecasting the density of portfolio returns, as stems from a density forecasting analysis based on the probability integral transform (PIT) paradigm

(Rosenblatt (1952), Diebold, et al. (1999)) and scoring rules for ranking density forecasting methods (Winkler (1967), Amisano & Giacomini (2007)).

Our SNP-DCC model is inspired by the fact that, up to the authors knowledge, none of the aforementioned non-Gaussian multivariate approaches formally admits the estimation in two stages proposed by Engle (2002). The solution provided by our approach in relation to the latter point, together with its other features, (i), (ii) and (iv) above, makes it a useful tool for financial econometrics research and applications.

The remainder of the article is divided into the following four sections. In Section 2, we present the methodology to define multivariate SNP densities, and discuss their properties. Section 3 describes a particular SNP-DCC model of interest for financial applications. Section 4 provides an empirical application to two bivariate portfolios composed by US stock returns, an exchange rate index and a stock returns index, to test the in- and out-of-sample performance of the proposed model. Section 5 summarizes the main conclusions.

2. Multivariate SNP distributions

The modeling of the multivariate distribution of financial variables faces serious obstacles that are still not fully resolved. For instance, the generalization of univariate marginal distributions to a multivariate framework has been successfully achieved by the use of copulas, but those models present drawbacks related with the integration of the joint distribution (e.g., to compute moments), which becomes analytically intractable and requires the implementation of highly computationally demanding numerical algorithms (see Jondeau et al. (2007) p. 196). On the other hand, the use of the existing heavy-tailed and skewed multivariate distributions are interesting alternatives, but in most cases those distributions cannot capture some of the salient features of financial returns due to the lack of a sufficiently flexible parametric structure. Moreover, the multivariate time-varying models can also be implemented for capturing conditional moments, but at the cost of a parameter structure that might give place to very complicated specifications for large-dimensional portfolios. That problem is known in the literature as the "dimensionality curse", and has been tackled with more parsimonious multivariate models and through estimation procedures in two stages, as in the DCC model. Nevertheless, the implementation of the latter process requires the separability of the log-likelihood function, and this property has been shown, so far in the literature, to be formally possible only under normality. This fact is an important limitation of the DCC model which was proposed to capture financial variables dynamics, but it is not able to capture the known leptokurtosis presented by those variables.

In this paper we present a different approach to the joint distribution of financial asset returns that solves some of the aforementioned shortcomings, and produces reasonably good empirical results. Specifically, we propose a methodology to generalize the univariate SNP-type of distributions to a multivariate framework, which preserves the good performance of the SNP distributions in terms of generality and flexibility, since the marginal distributions of the proposed joint density are univariate SNP densities. The methodology may also incorporate the Gallant & Nychka's (1987) methodology to ensure positivity, but the main stress is put on achieving the separability of the log-likelihood to be able to implement the two-stage estimation procedure established in the DCC model. For this purpose we initially define the multivariate pdf distribution of a random vector $X_t = (x_{1t}, x_{2t}, \cdots, x_{nt})' \in \Re^n$ with zero mean and uncorrelated variables as given in equation (1),

$$F^{\varsigma}(X_t, \gamma) = \frac{1}{n}\left[\prod_{i=1}^{n} g(x_{it})\right]\left[\sum_{i=1}^{n} \omega_i^{\varsigma} q_i^{\varsigma}(x_{it})\right] = \frac{(2\pi)^{-n/2}}{n}\exp\left\{-\frac{X_t' X_t}{2}\right\}\left[\sum_{i=1}^{n} \omega_i^{\varsigma} q_i^{\varsigma}(x_{it})\right], \quad \textbf{(1)}$$

where g(·) denotes a standard Gaussian density, $q_i^{\varsigma}(\cdot)$ (equation (2)) represents the Hermite polynomials expansion for the i-th variable (*i*=1,2,...,*n*), *m* is the truncation order, which without loss of generality is considered the same for all i, and ω_i^{ς} are the constants that make the marginal densities to integrate up to one,

$$q_i^{\varsigma}(x_{it}) = \begin{cases} 1 + \sum_{s=2}^{m} \gamma_{is} H_s(x_{it}), & \text{if } \varsigma = \mathrm{I}, \\ 1 + \sum_{s=2}^{m} \gamma_{is}^2 H_s(x_{it})^2, & \text{if } \varsigma = \mathrm{II}. \end{cases} \quad \textbf{(2)}$$

This distribution type involves different specifications depending on the assumed Hermite polynomials structure. Specifically, in this article we compare two different multivariate SNP alternatives, denoted with the index ζ=I,II. These distributions, named SNP_I and SNP_{II}, are inspired on the distributions in Perote (2004) and Del Brio et. al.

(2009), respectively, but in contrast with those distributions which consider a combination of a multivariate Gaussian density with a non-diagonal covariance matrix and a term that incorporates the Hermitian expansion for every variable, they are initially defined in terms of uncorrelated variables (i.e. correlation is introduced by means of linear restrictions). This idea of specifying the multivariate SNP density in these terms is the key to achieve the separability of the log-likelihood function as proposed by Engle (2002), and allows to formally implement two-step maximum likelihood estimation, as discussed in the next section.

The SNP_I distribution has a simpler structure than the SNP_{II} but, unlike the latter, it does not guarantee positivity for all the values of density parameters, γ_{is} $\forall i=1,2,...,n$ and $\forall s=2,...,m$. The Hermite polynomials, denoted by $H_s(\cdot)$, $\forall s\in\mathbb{N}$ ($H_0(\cdot)=1$), can be defined in terms of the s^{th} order derivative of the Gaussian pdf as,

$$\frac{d^s g(z)}{dz^s} = (-1)^s g(z) H_s(z). \quad \textbf{(3)}$$

$H_s(\cdot)$ satisfy, among others, the orthogonality properties given in equations (4), (5) and (6) below; see Kendall & Stuart (1977) for further details on Hermite polynomials properties,

$$\int H_s(z) g(z) dz = 0, \quad \forall s > 0 \quad \textbf{(4)}$$

$$\int H_s(z) H_j(z) g(z) dz = \begin{cases} 0, & \forall s \neq j, \\ s!, & \forall s \neq j, \end{cases} \quad \textbf{(5)}$$

$$\int H_s(z)^2 H_j(z)^2 g(z) dz = s!\,j!, \quad \forall s \neq j\,. \quad \textbf{(6)}$$

Under those orthogonality conditions, it can be straightforwardly shown that multivariate SNP_ζ (ζ=I,II) densities satisfy the following properties:

Property 1. The constants, ω_i^ς, *weighting* $q_i^\varsigma(\cdot)$, *are (by direct application of equation (5)) given by,*

$$\omega_i^{\varsigma} = \left[\int g(x_{it}) q_i^{\varsigma}(x_{it}) dx_{it}\right]^{-1} = \begin{cases} 1, & \text{if } \varsigma = \mathrm{I}, \\ \left[1 + \sum_{s=2}^{m} \gamma_{is}^2 s!\right]^{-1}, & \text{if } \varsigma = \mathrm{I}. \end{cases} \quad \textbf{(7)}$$

Property 2. The multivariate SNP$_I$ and SNP$_{II}$ functions integrate up to one (see Proof 1 in the Appendix).

Property 3. The marginal densities of the multivariate SNP$_I$ are the standard Gram-Charlier approximations, whilst the marginals of the multivariate SNP$_{II}$ are mixtures of univariate normal and univariate SNP of the type analyzed in Ñíguez & Perote (2004), as shown in equation (8) (see Proof 2 in the Appendix).

$$f_i^{\varsigma}(x_{it}) = \begin{cases} g(x_{it})\left[1 + \sum_{s=2}^{n} \frac{\gamma_{is}}{n} H_s(x_{it})\right], & \text{if } \varsigma = \mathrm{I}, \\ g(x_{it})\left[\frac{n-1}{n} + \frac{1}{n}\omega_i^{II} q_i^{II}(x_{it})\right], & \text{if } \varsigma = \mathrm{II}. \end{cases} \quad \textbf{(8)}$$

Property 4. All order moments of SNP$_I$ and SNP$_{II}$ exist and can be obtained in terms of the density parameters and the moments of the standard Normal density (μ_r $\forall r \in \mathbb{N}$), as displayed in equation (9),

$$E^{\varsigma}\left[x_{it}^r\right] = \begin{cases} \mu_r + \sum_{j=0}^{r} j! c_j \frac{\gamma_{ij}}{n}, & \text{if } \varsigma = \mathrm{I}, \ \forall r \in \aleph, \\ \left[\left((n-1)\omega_i^{II} + 1\right)\mu_r + \sum_{s=2}^{m} s! \gamma_{is}^2 \sum_{j=0}^{r/2} j! d_j\right], & \text{if } \varsigma = \mathrm{I}, \ \forall r \in \aleph \text{ even}, \end{cases} \quad \textbf{(9)}$$

where $\{c_j\}_{j=0}^{r}$ *is a sequence of constants such that* $x_{it}^r = \sum_{j=0}^{r} c_j H_j(x_{it})$, *e.g.,*

$$x_{it}^r = \begin{cases} H_1(x_{it}), & \text{if } r = 1, \\ H_2(x_{it}) + 1, & \text{if } r = 2, \\ H_3(x_{it}) + 3H_1(x_{it}), & \text{if } r = 3, \\ H_4(x_{it}) + 6H_2(x_{it}) + 3, & \text{if } r = 4, \end{cases} \quad \textbf{(10)}$$

and $\{d_j\}_{j=0}^{r/2}$ *is another sequence of constants such that* $x_{it}^r = \sum_{j=0}^{r/2} d_j H_j(x_{it})^2$ *, e.g.,*

$$x_{it}^r = \begin{cases} H_1(x_{it})^2, & \text{if } r=2, \\ H_2(x_{it})^2 + 2H_1(x_{it})^2 - 1, & \text{if } r=4, \\ H_3(x_{it})^2 + 6H_2(x_{it})^2 + 3H_1(x_{it})^2 - 6, & \text{if } r=6, \\ H_4(x_{it})^2 + 12H_3(x_{it})^2 + 30H_2(x_{it})^2 + 12H_1(x_{it})^2 - 21, & \text{if } r=8, \end{cases} \quad \textbf{(11)}$$

Proof 3 in the Appendix demonstrates this result by assuming (without loss of generality) r<m.

Property 5. The SNP cumulative distribution functions (cdf hereafter) can be easily computed by means of equations (12) and (13) (see Proof 4 in the Appendix).

$$\Pr[x_1 \le a_1, \cdots, x_n \le a_n]^{\varsigma} = \frac{1}{n}\sum_{i=1}^{n} \Psi^{\varsigma}(a_i)\left[\prod_{j=1, j\ne i}^{n} \Phi(a_j)\right], \quad \forall \varsigma = \mathrm{I}, \mathrm{II}, \quad \textbf{(12)}$$

where $\Phi(\cdot)$*,* $\Psi^{\mathrm{I}}(\cdot)$ *and* $\Psi^{\mathrm{II}}(\cdot)$ *stand for the cdfs of the standard Normal, Gram-Charlier expansion and Positive Edgeworth-Sargan (PES) (Ñíguez & Perote, 2004) univariate distributions, respectively.*

$$\Psi^{\varsigma}(a_i) = \begin{cases} \Phi(a_i) - g(a_i)\sum_{s=2}^{m} \gamma_{is} H_{s-1}(a_i), & \text{if } \varsigma = \mathrm{I}, \\ \Phi(a_i) - \omega_i g(a_i)\sum_{s=2}^{m} \gamma_{is}^2 \sum_{l=0}^{s-1} \frac{s! H_{s-1}(a_i) H_{s-1-1}(a_i)}{(s-l)!}, & \text{if } \varsigma = \mathrm{II}, \end{cases} \quad \textbf{(13)}$$

Property 6. For a given vector of quantiles $(a_1, a_2, \cdots, a_n)'$*, the difference in probabilities between the multivariate Gaussian and SNP densities can be obtained from the following closed formula (see Proof 5 in the Appendix).*

$$\Pr[x_1 \le a_1, \cdots, x_n \le a_n]^{N} - \Pr[x_1 \le a_1, \cdots, x_n \le a_n]^{\varsigma} == \frac{1}{n}\sum_{i=1}^{n} B^{\varsigma}(a_i)\left[\prod_{j=1, j\ne i}^{n} \Phi(a_j)\right], \quad \forall \varsigma = \mathrm{I}, \mathrm{II}, \quad \textbf{(14)}$$

where $\Pr[x_1 \le a_1, \cdots, x_n \le a_n]^N$ *and* $\Pr[x_1 \le a_1, \cdots, x_n \le a_n]^\zeta$ *stand for the multivariate cdfs of the standard Normal and* SNP_ζ *densities (*ζ=1,2*), respectively, and*

$$B^{\varsigma}(a_i) = \begin{cases} g(a_i)\sum_{s=2}^{m} \gamma_{is} H_{s-1}(a_i), & \text{if } \varsigma = \mathrm{I}, \\ \omega_i g(a_i)\sum_{s=2}^{m} \gamma_{is}^2 \sum_{l=0}^{s-1} \dfrac{s!\, H_{s-1}(a_i) H_{s-1-1}(a_i)}{(s-l)!}, & \text{if } \varsigma = \mathrm{II}, \end{cases} \qquad \textbf{(15)}$$

Properties 1-6 support the multivariate SNP as a very flexible (i.e. it can capture skewness, leptokurtosis, multimodality and most of the high frequency financial features through its general parametric structure) and easy to implement distribution (e.g. moments, probabilities and quantiles can be straightforwardly computed). Nevertheless, in spite of these interesting properties, this distribution would certainly be more useful if correlation among variables were incorporated. To do so, we transform the vector X_t such as the transformed variable, $U_t = \Sigma_t^{1/2} X_t$, has zero mean and variance-covariance matrix Σ_t, with $\Sigma_t = \Sigma_t^{1/2}\Sigma_t^{1/2}$ being the symmetric spectral decomposition, i.e. $\Sigma_t^{1/2} = C_t \Lambda_t^{1/2} C_t'$, where $\Lambda_t = \mathrm{diag}\{\lambda_{1t}, \lambda_{2t}, \cdots, \lambda_{2n}\}$ is the diagonal matrix of the eigenvalues of Σ_t, and C_t the corresponding orthogonal matrix of eigenvectors of Σ_t. Note that this decomposition of the matrix Σ_t, which is always possible for symmetric and positive definite matrices, yields the product of two identical symmetric matrices, unlike either the Cholesky decomposition (in terms of triangular matrices) or the "non symmetric" eigenvector decomposition ($\Sigma_t^{1/2} = C_t \Lambda_t^{1/2}$). Furthermore, note that if the variance and covariance matrix of X_t is given by $K_t^2 = \mathrm{diag}\{k_{1t}^2, k_{2t}^2, \cdots, k_{nt}^2\}$, then the vector X_t can be standardized by the following transformation: $X_t^* = K_t^{-1} X_t$. If so, the variance and covariance matrix of $U_t = \Sigma_t^{1/2} X_t^*$ can be interpreted in terms of the matrix Σ_t. However, if the focus of the empirical analysis is forecasting, the latter transformation is unnecessary.

Alternatively, we can write $U_t = D_t R_t^{1/2} X_t$, since Σ_t can be decomposed in terms of the diagonal matrix of conditional standard deviations, $D_t = \mathrm{diag}\{\sigma_{1t}, \cdots, \sigma_{nt}\}$, and the correlation matrix, R_t, as given in equation (16),

$$\Sigma_t = D_t R_t D_t = D_t R_t^{1/2} R_t^{1/2} D_t. \qquad \textbf{(16)}$$

Then, U_t is distributed according to a multivariate SNP distribution, whose pdf is displayed in equation (17).

$$F^{\varsigma}(U_t;\gamma) = (2\pi)^{-\frac{n}{2}} \left|\Sigma_t\right|^{-\frac{n}{2}} \exp\left\{-\frac{1}{2}U_t{}'\Sigma_t^{-1}U_t\right\}\left[\sum_{i=1}^{n}\omega_i^{\varsigma} q_i^{\varsigma}\left(\Sigma_t^{-\frac{1}{2}}U_t\right)\right]\frac{1}{n}, \quad \forall\varsigma = \mathrm{I},\mathrm{II}, \qquad \textbf{(17)}$$

Analogously, the SNP density can be re-written in terms of $E_t = D_t^{-1}U_t$ as,

$$F^{\varsigma}(E_t;\gamma) = (2\pi)^{-\frac{n}{2}} \left|R_t\right|^{-\frac{n}{2}} \exp\left\{-\frac{1}{2}E_t{}'R_t^{-1}E_t\right\}\left[\sum_{i=1}^{n}\omega_i^{\varsigma} q_i^{\varsigma}\left(R_t^{-\frac{1}{2}}E_t\right)\right]\frac{1}{n}, \quad \forall\varsigma = \mathrm{I},\mathrm{II}, \qquad \textbf{(18)}$$

In particular, for the bivariate case (i=1,2) the inverse transformation $X_t = R_t^{-1}E_t$, can be easily written as a function of the standardized variables, $\varepsilon_{it} = u_{it}/\sigma_{it}$, and time-varying correlation, ρ_t, as displayed in equation (19),

$$x_{it} = \begin{cases} \frac{1}{2}\left(\frac{1}{\sqrt{1+\rho_t}} + \frac{1}{\sqrt{1-\rho_t}}\right)\varepsilon_{1t} + \frac{1}{2}\left(\frac{1}{\sqrt{1+\rho_t}} - \frac{1}{\sqrt{1-\rho_t}}\right)\varepsilon_{2t}, & \text{if } i=1, \\ \frac{1}{2}\left(\frac{1}{\sqrt{1+\rho_t}} - \frac{1}{\sqrt{1-\rho_t}}\right)\varepsilon_{1t} + \frac{1}{2}\left(\frac{1}{\sqrt{1+\rho_t}} + \frac{1}{\sqrt{1-\rho_t}}\right)\varepsilon_{2t}, & \text{if } i=2, \end{cases} \qquad \textbf{(19)}$$

3. The multivariate SNP-DCC model

Let Y_t be a $n\times1$ vector of asset returns conditionally (on the information set Ω_{t-1}) distributed according to a multivariate SNP with conditional first and second moments defined by $\mu_t(\phi)$ and $\Sigma_t(\theta)=D_t(\alpha)R_t(\rho)D_t(\alpha)$, respectively, where ϕ, θ, α and ρ are parameter vectors.[2] Following Engle's (2002) DCC model specification, the matrices $D_t(\alpha)$ and $R_t(\rho)$ are modelled as displayed in equations (23) to (26); the equation (25) being the MARCH family of Ding & Engle (2001) where S is the unconditional correlation matrix, ξ is a vector of ones, A, B and $\xi\xi'-A-B$ are positive definite matrices, and $\circ$ is the Hadamard product of two identically sized matrices (computed by element by element multiplication).

[2] Usually either an AR(1) or MA(1) process is specified for μ_{t}(φ) selected according to information criteria to account for the small structure in the level of series of financial asset returns, see for instance, Sentana & Wadhwani (1992).

$$Y_t = \mu_t(\phi) + U_t, \tag{20}$$

$$U_t \big| \Omega_{t-1} \approx SNP(0, \Sigma_t(\theta)), \tag{21}$$

$$\Sigma_t(\theta) = D_t(\alpha) R_t(\rho) D_t(\alpha) = D_t(\alpha) R_t(\rho)^{1/2} R_t(\rho)^{1/2} D_t(\alpha), \tag{22}$$

$$D_t^2 = diag\{\alpha_{i0}\} + diag\{\alpha_{i1}\} \circ U_{t-1} U_{t-1}' + diag\{\alpha_{i2}\} \circ D_{t-1}^2, \tag{23}$$

$$E_t = D_t^{-1} U_t, \tag{24}$$

$$Q_t = S \circ (\xi\xi' - A - B) + A \circ E_{t-1} E_{t-1}' + B \circ Q_{t-1}, \tag{25}$$

$$R_t = diag\{Q_t\}^{-1/2} Q_t \, diag\{Q_t\}^{-1/2}, \tag{26}$$

This model, named SNP-DCC, encompasses the (Gaussian)-DCC, and presents a log-likelihood which (as the one of the (Gaussian)-DCC) can be split into two different components: (i) the mean-volatility part, $L_{MV}(Y_t,\eta)$, where $\eta=(\phi',\alpha')'$, and (ii) the "standardized" SNP component, $L_{SNP}^{\zeta}(E_t,\eta,\varphi)$, where $\varphi=(\rho',\gamma')'$ includes the correlation and the shape parameters (see *Proof 6* in the Appendix). Specifically, these two terms can be written (after deleting the unnecessary constants) as given in equations (27) and (28).

$$L_{MV}(Y_t,\eta) = -\frac{1}{2}\sum_{i=1}^{n}\left[T\log(2\pi) + \sum_{t=1}^{T}\left(\ln(\sigma_{it}^2) + \frac{(y_{it}-\mu_{it})^2}{\sigma_{it}^2}\right)\right] = -\frac{1}{2}\sum_{i=1}^{n}\left[T\log(2\pi) + L_{MV_i}(\eta_i)\right], \tag{27}$$

$$L_{SNP}^{\varsigma}(E_t,\eta,\varphi) = -\frac{1}{2}\sum_{t=1}^{T}\left\{\ln|R_t| + E_t' R_t^{-1} E_t - 2\ln\left[\sum_{i=1}^{n}\omega_i^{\varsigma} q_i^{\varsigma}\left(R_t^{-\frac{1}{2}} E_t\right)\right]\right\}, \quad \forall \varsigma = \mathrm{I}, \mathrm{II}. \tag{28}$$

Thus, the SNP-DCC model can be estimated by ML in two steps as follows: first, η is obtained by maximizing independently $L_{MVi}(y_{it},\eta_i)$ for each i=1,2,...,n (note that this step assumes normality), and second, the conditional correlation parameters and the multivariate SNP shaping parameters, φ, are jointly estimated in the log-likelihood function concentrated with respect to $\hat{\eta}$=argmax{$L_{MV}(Y_t,\eta)$}, i.e. $L_{SNP}^{\zeta}(E_t,\hat{\eta},\varphi)$. As pointed out by Engle (2002), this two-step estimation problem can be interpreted in terms of the joint Generalized Method of Moments estimation framework discussed in Section 6.1 of Newey & McFadden (1994). Particularly, if the conditions $\frac{1}{T}\sum_{t=1}^{T}\nabla_{\eta} L_{MV}(Y_t,\eta) = 0$ and $\frac{1}{T}\sum_{t=1}^{T}\nabla_{\varphi} L_{SNP}^{\varsigma}(E_t,\hat{\eta},\varphi) = 0$ are satisfied with probability approaching one, $\hat{\eta} \xrightarrow{P} \eta_0$, $\hat{\varphi} \xrightarrow{P} \varphi_0$, and under the regularity conditions (i)-(v) of Theorem 3.4 in Newey & McFadden (1994), then $\hat{\eta}$ and $\hat{\varphi}$ are asymptotically Normal, and

$$\sqrt{T}\left(\hat{\varphi} - \varphi_0\right) \xrightarrow{d} N(0,V), \tag{29}$$

$$V = \left[E\left(\nabla_{\varphi\varphi} L^{\varsigma}_{SNP}\right)\right]^{-1} E\left(HH'\right)^{-1} \left[E\left(\nabla_{\varphi\varphi} L^{\varsigma}_{SNP}\right)\right]^{-1}, \tag{30}$$

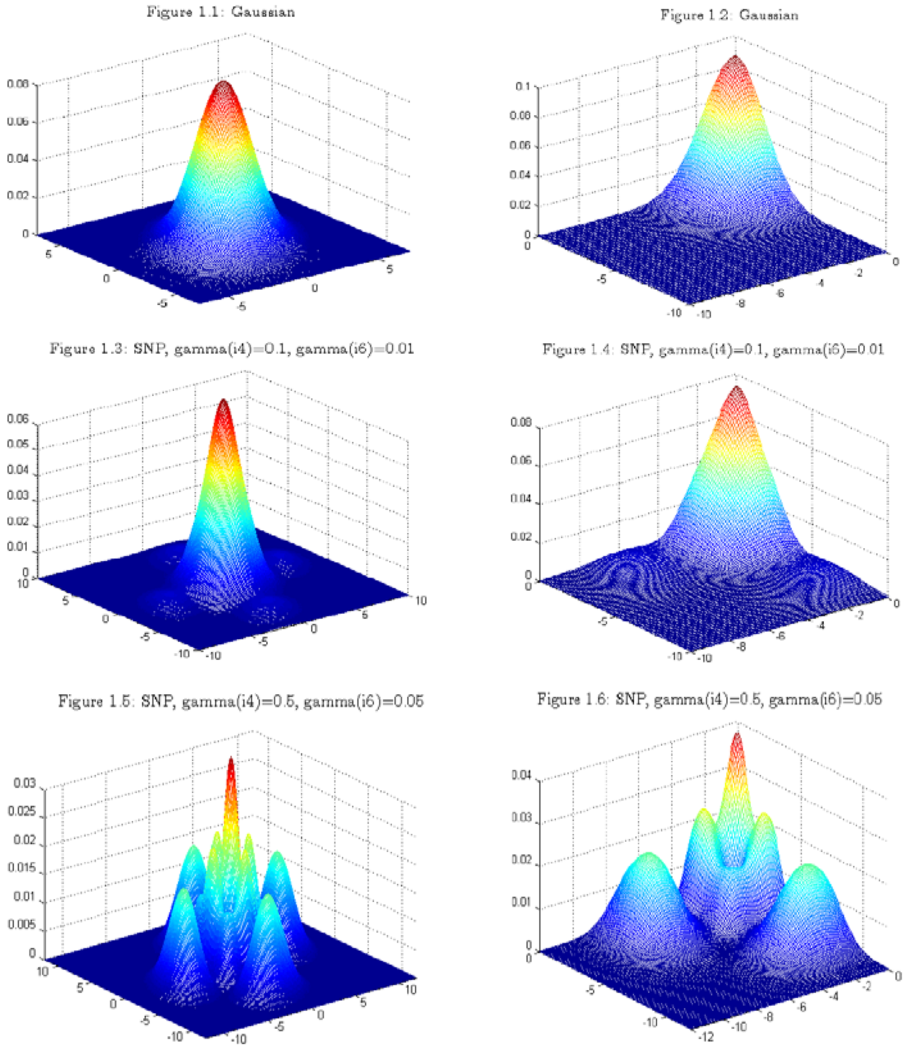
$$H = \nabla_{\varphi} L^{\varsigma}_{SNP} - E\left(\nabla_{\varphi\eta} L^{\varsigma}_{SNP}\right)\left[E\left(\nabla_{\eta\eta} L_{MV}\right)\right]^{-1} \nabla_{\eta} L_{MV}, \tag{31}$$

with $\nabla_{\eta}(\square)$ and $\nabla_{\eta\varphi}(\square)$ denoting the gradient vector of first derivatives with respect to the variables in η and the Hessian matrix of the second derivatives with respect to η and □, respectively, (see Theorem 6.1 in Newey & McFadden (1994) and its application to the DCC model in Engle (2002) and Engle & Sheppard (2001) for further details). It must be noted that in the context of the SNP-DCC, the first step is QMLE, but the second step is MLE since the likelihood corresponds to the SNP density. Nevertheless we argue that the second-step MLE is also consistent and asymptotically normal as *n*→∞, since the multivariate (infinite) SNP expansion is almost surely the "true" density (Sargan (1975) and Gallant & Nychka (1987)). Moreover, the asymptotic variances of the GARCH parameters are the robust variance and covariance matrix in Bollerslev & Wooldridge (1992), but the asymptotic variance and covariance matrix of the estimates of the second step parameters involves a more complex structure (see Engle & Sheppard, 2001). Furthermore, the estimates of the SNP-DCC parameters are not fully efficient since they are estimated by Limited Information MLE, although the estimates of the SNP-DCC model are more efficient than those of the DCC models provided that γ≠0. However, following Pagan (1986), an asymptotically efficient estimator can be obtained by performing an additional iteration of the Newton-Raphson algorithm for the joint model starting from the two steps consistent (Q)MLE.

On the other hand, it must be noted though that for the SNP-DCC, consistency of the second-step cannot be guaranteed in practice since the Gram-Charlier expansions need to be truncated. Nonetheless, we argue that the density misspecification error can be minimized by selecting the truncation order of the SNP density according to, for instance, Wald specification tests or Information Criteria. In any case, the two-step SNP-DCC is consistent provided that the SNP distribution is correctly specified, unlike other non-Gaussian distributions widely used (e.g. in financial applications) to model departures from normality, for which the consistency of the DCC two-step estimation cannot be formally proven, even under correct density specification, since the log-likelihood is not separable (see Newey & Steigerwald (1997), Bauwens & Laurent (2005), Jondeau & Rockinger (2005) and Jondeau et al. (2007)). A further discussion of the estimation procedure for a truncated SNP-DCC model is provided in Section 4.

Finally, Figure 1 plots the bivariate Gaussian density and the allowable shapes of a bivariate symmetric SNP_{II} density for different values of its parameters (as orientating illustrations we display the cases of (d_{i4},d_{i6})=(0,0), (d_{i4},d_{i6})=(0.1,0.01) and (d_{i4},d_{i6})=(0.5,0.05)). The figures in the left column highlight the tail shape of the densities. It is striking to see the flexibility presented by the SNP density, which is an advantage to fit any empirical distribution, especially in the tails (see also Del Brio, et al. (2009) for further examples on the flexibility of other SNP related multivariate densities). We investigate further the effect of this feature on the performance of a SNP-DCC model in the forecasting exercise of next section.

FIGURE 1
Plots of Bivariate Gaussian and SNP Distributions



Notes: Plots of bivariate Gaussian, and SNP_{II} densities with different allowable shapes depending on their γ_{is} (gamma(is)) parameters ($i = 1, 2$).

4. An empirical application to portfolio returns

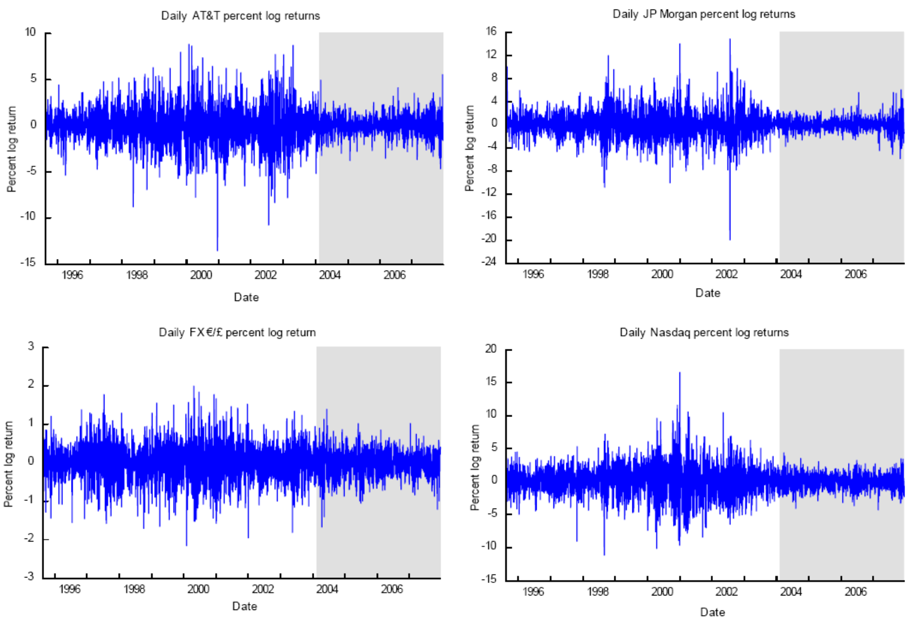
4.1. The data

In this section we investigate the empirical performance of the models discussed above through an in- and out-of-sample comparative analysis. To do so, we consider three types of distributions with either constant or dynamic conditional correlation, which formally admit two-step estimation procedures. The models that we get are then the following: Gaussian (CCC and DCC), non-positive-SNP (SNP_{I}-CCC and SNP_{II}-DCC) and positive-SNP (SNP_{II}-CCC and SNP_{II}-DCC). The data used are (daily) percent log returns computed from a observed sample of (daily) asset prices, y_{it}=100log(P_{it}/ P_{it-1}), of two (representative) stocks from the Dow Jones index (AT&T and JP Morgan), the Euro(€)/British Pound(£) exchange rate (FX €/£), and the Nasdaq index. We consider two bivariate portfolios: Portfolio AT&T-JP Morgan, and Portfolio

FX €/£-Nasdaq, with returns denoted as $Y_t=(y_{1t}, y_{2t})$. All series are sampled over the period August 17, 1995 to December 17, 2007 for a total of 3,218 observations. The data were obtained from Datastream. Figure 2 displays the plots of the four return series for the total sample. The shaded area in those plots corresponds to the out-of-sample period (February 17, 2004 to December 17, 2007 for a total of N=1,000 observations) used for the forecasting analysis in the next section.

FIGURE 2

Plots of daily log returns



Notes: Plots of daily AT&T, JP Morgan, FX €/£ and Nasdaq log returns. In-sample period: 16/08/1995 - 16/02/2004. Out-sample period (graphs shaded area): 17/02/2004 - 17/12/2007. Total observations: 3218.

Table 1 reports some descriptive statistics for the total samples. As expected the stock returns series are much more volatile (as measured by the sample standard deviation) than the FX €/£ series. The unconditional distribution of any of these series shows clearly non-Gaussian features, such as (mild) skewness, and a remarked excess of kurtosis over the Normal distribution. The Jarque-Bera test for normality is easily rejected for the four time series. The analysis of dependence through the Ljung-Box portmanteau test statistic (Q_{LB}) shows some form of weak dependence in the level and a strong correlation in the second-order moment of all series. The asset returns of Portfolio AT&T-JP Morgan present a higher correlation than those of Portfolio FX €/£-Nasdaq. The Likelihood ratio (LR) test for model specification SNP_{II}-DCC versus DCC rejects the null hypothesis H_0: $\gamma_{i2}=\gamma_{i4}=\gamma_{i6}=0$ ($\forall i$=1,2) in favour of the SNP_{II}-DCC model for both portfolios.

TABLE 1

Daily percent log returns descriptive statistics

	Portfolio AT&T - JP Morgan		Portfolio FX €/£ - Nasdaq	
	AT&T	JP Morgan	FX €/£	Nasdaq
Sample	17/08/1995 - 17/12/2007			
Observations	3218			
Mean	0.0160	0.0281	0.0045	0.0294
Median	0.0000	0.0000	0.0211	0.0509
Maximum	8.8337	14.872	1.9909	16.582
Minimum	-13.537	-19.976	-2.1558	-11.139
St. Dev.	1.8610	2.1585	0.4576	2.1451
Skewness	-0.0921	0.0915	-0.1491	0.1385
Kurtosis	6.3862	9.0895	4.2911	6.6315
Jarque-Bera	1542.0*	4976.6*	235.47*	1778.5*
$Q_{LB}(1) - r_t$	1.6591	0.0147	8.3632*	6.1489*
$Q_{LB}(1) - r_t^2$	68.587*	209.91*	64.927*	160.6*
$Q_{LB}(20) - r_t^2$	729.73*	1127.3*	578.09*	2028.7*
$\widehat{\rho}$	0.3223		0.0557	
$\text{LR}_{SNP-DCC_{II} \text{ vs } DCC}$	3186.2*		3130.7*	

Notes: The Jarque-Bera normality test is asymptotically distributed as a $\chi^2(2)$ under the null of normality. $\widehat{\rho}$ denotes the sample correlation coefficient for the returns of each bivariate portfolio. $Q_{LB}(\varsigma)$ denotes the Ljung-Box Q-statistic which is asymptotically distributed as $\chi^2(\varsigma)$, ς being the autocorrelation order. The Likelihood Ratio (LR) test is asymptotically distributed as $\chi^2(\iota)$ being ι the number of restrictions under the null —the LR test results reported correspond to the SNP-DCC$_{II}$ model for the null $H_0 : \gamma_{i2} = \gamma_{i4} = \gamma_{i6} = 0$ $(i = 1, 2)$. The critical values of $\chi^2(1)$, $\chi^2(2)$, $\chi^2(6)$ and $\chi^2(20)$ are 3.84, 5.99, 12.59 and 31.41, at 5% significance level, respectively. The asterisk (*) denotes rejection of the null hypothesis of the corresponding test at least at 5% significance level.

4.2. Estimation and in-sample analysis

The estimation is carried out in two stages by (Q)MLE techniques, using a moving in-sample window of constant size T=2,217 observations. In the first stage, an AR(1) process for the conditional mean (selected according to the Akaike Information Criteria (AIC hereafter)) and a GARCH(1,1) process for the conditional variance are jointly estimated (under normality) independently for each asset. Then, in the second stage, the standardized residuals from the previous step are used to estimate the conditional correlation equation and the rest of the density parameters. The first stage yields QMLE which is consistent and asymptotically normal, although not efficient. Our second stage MLE is not a priory consistent, since we use a truncated SNP density, but it may be more efficient than the second step QMLE of the Gaussian-DCC. Thus, we argue that the better our truncated SNP density can approximate the "true" distribution, the more efficient is our second stage MLE. Finally, following Pagan (1996) a further Newton-Raphson iteration without line search for the joint model is performed from the first and second stage (Q)MLE: the estimates do not change but the information matrix is now block diagonal, thus obtaining estimators asymptotically equivalent to joint QMLE. Robust standard errors were computed following Bollerslev & Wooldridge (1992). Taking into account the limitations in the estimation of the truncated SNP-DCC model, the model performance is mainly evaluated in an out-of-sample forecasting framework, in which possible losses in efficiency and consistency are not crucial (see Ruiz & Pascual 2002).

The likelihood functions in each step are maximized using the Berndt, Hall, Hall & Hausman (1974) algorithm. We observe that the estimation of the SNP models is not computationally very demanding providing that starting values are chosen properly. As it is known that SNP densities may present multiple local modes, the optimization is monitored using different starting values to ensure that the (Q)MLE we obtain are global optima.

Table 2 presents the estimation results of the bivariate models. $\alpha_{i\tau}$, i=1,2 and τ =0,1,2, denote the parameters of the GARCH(1,1) models used for the conditional variances, ϕ_{i0} and ϕ_{i1} denote the intercept and the slope, respectively, of the AR(1) process for the conditional mean, and ρ denotes the correlation parameter in CCC models. The rest of parameters displayed in the table follow the same notation used in previous sections. Robust standard errors are in parenthesis next to the parameter estimates. We observed that the presented (Newton-Raphson corrected) standard errors did not change much in relation to those from the separated two-step estimation.

For the specification of the SNP models we started considering densities truncated at the eighth moment, then persistently (across windows) non-significant parameters were removed. In Table 1 we present the final SNP specifications. For both portfolios, the estimated SNP densities are unconditionally symmetric since the odd parameters, γ_{is} s=3,5,7, are not significant at any reasonable significance level. For Portfolio AT&T-JP Morgan, the even parameters of the SNP_{I}, γ_{12} and γ_{16}, were not statistically significant, although they were not removed from the model for the sake of clear comparisons across SNP models. The SNP_{II} models have three significant even parameters for the first asset (γ_{1s}, s=2,4,6) and two significant even parameters for the second asset (γ_{2s}, s=4,6). For Portfolio FX €/£-Nasdaq, the existing leptokurtosis in the distribution of the first data window is gathered mainly by γ_{14}, γ_{24} and γ_{26} in SNP_{I} models, and by γ_{14} and γ_{26} in SNP_{II} models. It is interesting to note that, the obtained estimates $\hat{\gamma}_{i4}$ and $\hat{\gamma}_{i6}$ for both portfolios, are smaller than those considered in Figures 1.3 and 1.4, and therefore the evidence of multimodality in our data is mild. Nonetheless, the heavy tails of the returns distribution do not necessarily decrease uniformly, as they would do under the commonly assumed parametric distributions in most financial econometrics applications.

According to the AIC, defined as AIC=2(□-ln*L*)/*n* (□ being the number of the parameters of the model), we observe that SNP models provide a notably better goodness-of-fit than Gaussian models, and that dynamic conditional correlation helps the models to fit the data. Furthermore, among SNP models, SNP_{I} are preferred to their SNP_{II} counterparts. Regarding the conditional mean and variance estimates, we observe the usual small structure in the conditional mean and high persistence in the conditional variance, that is also observed in the conditional correlation (in line with the results in Engle & Sheppard (2001) and Engle (2002) for US stock returns). Also the obtained estimates of the unconditional correlation coefficient, ρ, given by CCC and SNP-CCC models are close to the sample correlations reported in Table 2.

TABLE 2

Estimation results

Mean equation: $y_{it} = \phi_{i0} + \phi_{i1} y_{i,t-1} + u_{it}, \;\; u_{it} = \varepsilon_{it}\sigma_{it}, \;\; i = 1, 2.$

Variance equation: $\sigma^2_{it} = \alpha_{i0} + \alpha_{i1} u^2_{i,t-1} + \alpha_{i2}\sigma^2_{i,t-1}.$

Correlation equation: $\rho_t = (1 - \delta_1 - \delta_2)\overline{\rho} + \delta_1 \varepsilon_{1t-1}\varepsilon_{2t-1} + \delta_2 \rho_{t-1}.$

	CCC	DCC	SNP_I-CCC	SNP_I-DCC	SNP_{II}-CCC	SNP_{II}-DCC
			Panel 1: Portfolio AT&T - JP Morgan			
Stage 1						
ϕ_{10}			.0343 (1.21)			
ϕ_{11}			-.0494 (-2.23)			
α_{10}			.0362 (1.65)			
α_{11}			.0577 (3.08)			
α_{12}			.9360 (45.1)			
ϕ_{20}			.0990 (2.08)			
ϕ_{21}			.0343 (1.61)			
α_{20}			.0318 (1.66)			
α_{21}			.0551 (4.53)			
α_{22}			.9407 (69.5)			
Stage 2						
γ_{12}			.0037 (0.12)	.0010 (0.07)	.0913 (1.63)	.0888 (1.59)
γ_{14}			.0912 (6.43)	.0914 (6.55)	.0281 (3.57)	.0267 (3.15)
γ_{16}			.0012 (0.54)	.0013 (0.55)	.0021 (2.03)	.0020 (1.56)
γ_{22}			.0001 (0.11)	.0001 (0.24)	.0001 (0.03)	.0001 (0.73)
γ_{24}			.0902 (6.71)	.0904 (6.71)	-.0293 (-4.95)	-.0283 (-4.79)
γ_{26}			.0062 (2.43)	.0060 (2.31)	.0031 (3.12)	.0031 (3.13)
ρ	.2859 (13.5)		.2904 (14.1)		.3240 (14.4)	
δ_1		.0077 (4.19)		.0077 (4.27)		.0085 (4.65)
δ_2		.9877 (329)		.9880 (348)		.9880 (365)
AIC	1.9137	1.9043	.4539	.4446	.4798	.4727

	CCC	DCC	SNP_I-CCC	SNP_I-DCC	SNP_{II}-CCC	SNP_{II}-DCC
	Panel 2: Portfolio FX €/£ - Nasdaq					
Stage 1						
ϕ_{10}	.0072 (0.73)					
ϕ_{11}	-.0689 (-3.02)					
α_{10}	.0035 (1.09)					
α_{11}	.0382 (2.21)					
α_{12}	.9474 (33.1)					
ϕ_{20}	.1063 (2.34)					
ϕ_{21}	-.0387 (-1.83)					
α_{20}	.0571 (1.67)					
α_{21}	.0659 (3.37)					
α_{22}	.9246 (39.7)					
Stage 2						
γ_{12}			-.0114 (-0.33)	-.0115 (-0.33)	-.0001 (-0.03)	.0001 (0.13)
γ_{14}			.0647 (4.43)	.0649 (4.44)	.0270 (4.58)	.0269 (4.55)
γ_{16}			.0037 (1.37)	.0037 (1.37)	.0011 (0.64)	.0012 (0.71)
γ_{22}			-.0229 (-0.73)	-.0234 (-0.77)	-.0001 (-0.05)	.0001 (0.10)
γ_{24}			.0235 (2.10)	.0227 (2.02)	.0059 (0.31)	-.0003 (-0.11)
γ_{26}			.0039 (2.00)	.0039 (1.99)	.0029 (3.43)	.0031 (4.07)
ρ	.0642 (2.78)		.0591 (2.66)		.0612 (2.54)	
δ_1		.0090 (1.93)		.0075 (1.12)		.0091 (1.63)
δ_2		.9748 (68.3)		.9802 (38.4)		.9768 (53.1)
AIC	1.9924	1.9901	.5837	.5810	.5858	.5833

Notes: The coefficients presented in this table are (Q)ML estimates of the CCC, DCC, SNP-CCC and SNP-DCC models, for the bivariate portfolios returns. ϕ_{is} $(s = 0, 1)$ stand for the AR(1) parameters of the conditional means and α_{is} $(s = 0, 1, 2)$ for the GARCH(1,1) parameters of the conditional variances. ρ denotes the unconditional correlation parameter in CCC models and δ_s $(s = 1, 2)$ the conditional correlation parameters in DCC models. γ_{is} $(s = 2, 4, 6)$ denote the order s polynomial weighting parameter in the SNP models. t statistics calculated from robust standard errors are in parenthesis. Akaike Information Criterion (AIC) is displayed in the last row.

4.3. Density forecasting

In this section we test the performance for full density forecasting of the SNP_{II}-DCC model in comparison with the DCC model. Forecasts are produced by using a rolling window of size N that discards old observations. The recursive optimization is monitored by using the same starting value for all windows, instead of using the usual optimum from the previous data window. This mechanism is used to avoid getting trapped in successive local optima. On the other hand, it is worth noting that although the SNP_I-DCC is in principle a candidate to provide a good forecasting performance, it is not a suitable model in a forecasting experiment that involves data rolling windows over a long time period, since a combination of parameter estimates during the optimization process for a given window may lead to a negative value of the density. In this paper, we have addressed that problem by defining the SNP_{II} distribution for which positivity is guaranteed through reformulation of the density function. Furthermore, we consider models with DCC structures given their better in-sample fit in relation to their CCC counterparts (as shown in Table 1). Thus, SNP_{II}-DCC and (Gaussian)-DCC models are compared with respect to their density forecasting performance using the following criteria:

1. The PIT paradigm (Pearson (1933), Rosenblatt (1952), Diebold et al. (1998, 1999)) establishes that if $\{y_{it}^*\}_{t=T+1}^{T+N}$ is a series of realizations generated from a series of conditional densities, $\{f(y_{it}|\Omega_{t-1})\}_{t=T+1}^{T+N} = \{f_{i,t-1}(y_{it})\}_{t=T+1}^{T+N}$, and $\{\tilde{f}_{i,t-1}(y_{it})\}_{t=T+1}^{T+N}$ is a series of one-step-ahead density forecasts, then, the series of PIT of $\{y_{it}^*\}_{t=T+1}^{T+N}$ with respect to $\{\tilde{f}_{i,t-1}(y_{it})\}_{t=T+1}^{T+N}$ is i.i.d. U(0,1), i.e.

$$\{p_{it}\}_{t=T+1}^{T+N} = \left\{\int_{-\infty}^{y_{it}^*} \tilde{f}_{i,t-1}(y_{it})dy_{it}\right\}_{t=T+1}^{T+N} \overset{i.i.d.}{\approx} U(0,1), \qquad \textbf{(32)}$$

provided that the forecast densities match the actual densities at each t. Diebold et al. (1999) showed that the application of the PIT paradigm in a multivariate framework can be performed based on the PIT of the realized series with respect to the marginal and conditional one-step-ahead density forecasts as shown in equations (33) and (34), respectively, for the bivariate case (*i,j*=1,2) of the SNP_{II},

$$p_{it} = \int_{-\infty}^{y_{it}^*} \tilde{f}_{i,t-1}^{II}(y_{it})dy_{it}, \quad \forall t = T+1,\dots,T+N, \qquad \textbf{(33)}$$

$$p_{i|j,t} = \frac{\int_{-\infty}^{y_{it}^*}\int_{-\infty}^{y_{jt}^*} \tilde{F}_{t-1}^{II}(y_{it}, y_{jt})dy_{it}dy_{jt}}{\int_{-\infty}^{y_{jt}^*} \tilde{f}_{j,t-1}^{II}(y_{jt})dy_{jt}}, \quad \forall t = T+1,\dots,T+N. \qquad \textbf{(34)}$$

where $\tilde{f}_{i,t-1}^{II}(\square)$ and $\tilde{F}_{t-1}^{II}(\square,\square)$ stand for the one-step ahead marginal and joint density forecasts of the standardized SNP_{II}-DCC distribution, which are given by equations (35) and (36), respectively.[3]

$$\tilde{f}_{i,t-1}^{II}(y_{it}) = \frac{1}{2\tilde{\sigma}_{it}} g\left(\frac{y_{it}-\tilde{\mu}_{it}}{\tilde{\sigma}_{it}}\right)\left[1+\hat{\omega}_i^{II}\hat{q}_i^{II}\left(\frac{y_{it}-\tilde{\mu}_{it}}{\tilde{\sigma}_{it}}\right)\right], \qquad \textbf{(35)}$$

[3] It is worth mentioning that the PIT paradigm does not directly apply to the joint multivariate density (what certainly constitutes an interesting subject of research in the area of density forecasting evaluation), but it does to marginals and conditionals of the multivariate density, as shown by Diebold et al. (1999).

$$F_{t-1}^{II}(Y_t) = \frac{\left|\tilde{\Sigma}_t\right|^{-\frac{1}{2}}}{2\sqrt{2\pi}} \exp\left\{-\frac{1}{2}(Y_t - \tilde{\mu}_t)'\tilde{\Sigma}_t^{-1}(Y_t - \tilde{\mu}_t)'\right\}\left[\sum_{i=1}^{2} \hat{\omega}_i^{II} q_i^{II}\left(\frac{y_{it} - \tilde{\mu}_{it}}{\tilde{\sigma}_{it}}\right)\right]. \quad \textbf{(36)}$$

Note that the forecasted densities are computed for the one-step-ahead forecasts of the conditional means, variances and correlation, denoted by $\tilde{\mu}_{is}$, $\tilde{\sigma}_{it}$ $\forall i$=1,2 and $\tilde{\rho}_t$, respectively, and the estimates of the rest of the density parameters ($\hat{\gamma}_{is}$,$\forall i$=1,2 and $\forall s$=2,4,6) conditioned on the available information set Ω_{t-1}, $t=T+1,...,T+N$.[4] Note also that for the bivariate case $Y_t=(y_{1t},y_{2t})'$, $\tilde{\mu}_t = (\tilde{\mu}_{1t}, \tilde{\mu}_{2t})$, $\tilde{\Sigma}_t$ is the 2×2 one-step-ahead forecasted conditional variance and covariance matrix, $\hat{\omega}_i^{II} = \left(1 + \sum_{s=2}^{m} \hat{\gamma}_{is}^2 s!\right)^{-1}$ and $\hat{q}_i^{II}(.) = 1 + \sum_{s=2}^{m} \hat{\gamma}_{is}^2 H_s(.)$. We consider bivariate portfolios for the sake of simplicity since considering a larger portfolio would make the density forecasting analysis much more complicated, likely to obtain similar conclusions. Since the PIT series $\{p_{it}\}_{t=T+1}^{T+N}$ and $\{p_{i|j,t}\}_{t=T+1}^{T+N}$ are also interpreted as the p-values corresponding to the series of quantiles $\{y_{it}^*\}_{t=T+1}^{T+N}$ of the forecasted marginal and conditional densities, respectively, we use p-value discrepancy plots (i.e. plotting $\hat{P}_{p_{it}}(y_l) - y_l$ against y_l) (Davidson and MacKinnon (1998) and Fiorentini, Sentana and Calzolari (2003)), to test for correct model specification, where $\hat{P}_{p_{it}}(y_l)$ is the cdf of p_{it} calculated as $\hat{P}_{p_{it}}(y_l) - y_l = \frac{1}{N}\sum_{t=T+1}^{T+N} 1(p_{it} \le y_l)$, with 1{•} being an indicator function and y_l an arbitrary grid of l points.[5] Therefore, under correct model specification, the variable $\hat{P}_{p_{it}}(y_l) - y_l$ must converge to zero. The $p_{i|j,t}$ sequences can be analyzed analogously.

2. Scoring rules (Winkler (1967), Amisano & Giacomini (2007), Gneiting & Raftery (2007)). A scoring rule is a loss function $\psi(\hat{f}, Y^*)$ whose arguments are the density

---

[4] The parameter set might also be forecasted if time-varying conditional models for modeling higher order moments are implemented in the SNP framework (see León et al. (2005) and Ñíguez, Perote and Rubia (2009) for applications to the univariate case). This is certainly possible and constitutes a clear advantage of the SNP approach, although we leave this topic as an open question for further research.

[5] Particularly, we use a □=215 points grid that is finer in its extremes to highlight the models forecasting performance of the distribution tails, y_l =0.001,0.002,...,0.01,0.015,...,0.99,0.991,0.992,...,0.999.

forecast $\tilde{f}$ and the realisation Y^* of the future observation of the variable. In this paper we use the logarithmic scoring rule $\psi(\hat{f}, Y^*) = -\log \tilde{f}(Y^*)$ to compare marginal and conditional density forecasts. This is a (strictly proper) scoring rule that rewards a density forecast that assigns high probability to the event that actually occurred.[6] Density forecast models can be ranked by comparing their average scores, $\overline{\psi}(\tilde{f}, Y^*) = -N^{-1}\sum_{t=T+1}^{T+N} \log \tilde{f}_{t-1}(y_t^*)$. We take the logarithmic scoring rule as a negatively oriented penalty so, we prefer model *f* if $\overline{\psi}(\tilde{f}, Y^*) < \overline{\psi}(\tilde{g}, Y^*)$, and prefer model *g* otherwise. The null hypothesis H_0: $E\left[\psi(\tilde{f}, Y^*) - \psi(\tilde{g}, Y^*)\right] = 0$ is tested using Amisano & Giacomini (2007) test.

The results in Figure 3 and Table 3 show that the bivariate SNP_{II} distribution provides overall a better performance for forecasting the full density than the Normal. Specifically, the plots in Figure 3 show a remarkable better performable of the SNP-DCC over the DCC at the 5% lower tail, which is highlighted (right column plots in Figure 3) because of its direct relation with widely used financial risk measures such as Value-at-Risk and short-fall probabilities. On the other hand, if we look at higher percentiles, e.g. in the range [0.05,0.4], the results are mixed but tend to favour the DCC model. Furthermore, Table 3 provides clear evidence in favour of the SNP-DCC for full density forecasting, as the average logarithmic scores from the SNP-DCC model are significantly lower than those obtained from the DCC model. It is worth noting that the observed differences are due to the density specification, since forecasted means and volatilities from both distributions are exactly the same and differences in forecasted conditional correlations are very small. Our empirical results show evidence on that the extra term in the SNP_{II} distribution with respect to the Normal (see equation (15)) provides the SNP_{II} with enough flexibility to adapt to higher and possibly irregular frequencies at the lower percentiles (see right columns of Figure 3), and to more density around its mean.[7] These results are not surprising since leptokurtic models tend to show significantly better performance the lower the quantile of the forecasted density; besides, they are in line with previous findings in the literature: e.g. Fiorentini et al. (2003) show through the same graphical procedures used in this section, that a Student's t distribution provides a better performance than a Normal for fitting the full

[6] Examples of strictly proper scoring rules include the logarithmic, quadratic or sferical (Matheson & Winkler (1976), Gneiting & Raftery (2007)).

[7] The differences between the forecasted PITs under the multivariate (gaussian)-DCC and SNP-DCC models can be directly computed from the equations (14) and (15), provided that the differences between the forecasted correlations between both models are negligible.

density of stock returns, and Ñíguez & Perote (2004) provide evidence on gains of the PES density with respect to Gaussian and Student's t for full density forecasting, both papers consider empirical applications to asset returns in a univariate framework. On the other hand, in the multivariate context, Perote (2004) showed that multivariate SNP distributions involve more accurate in-sample fits of asset return distributions than Student's t or Gaussian, and Del Brio et al. (2009) show evidence of superior performance of multivariate SNP-CCC models with respect to Gaussian models for asset portfolio data. The results of our analysis show that SNP-DCC models provide a reasonably better performance than (Gaussian) DCC models for forecasting the full and lower percentile of the density of asset portfolio returns.

TABLE 3

Density forecasting performance

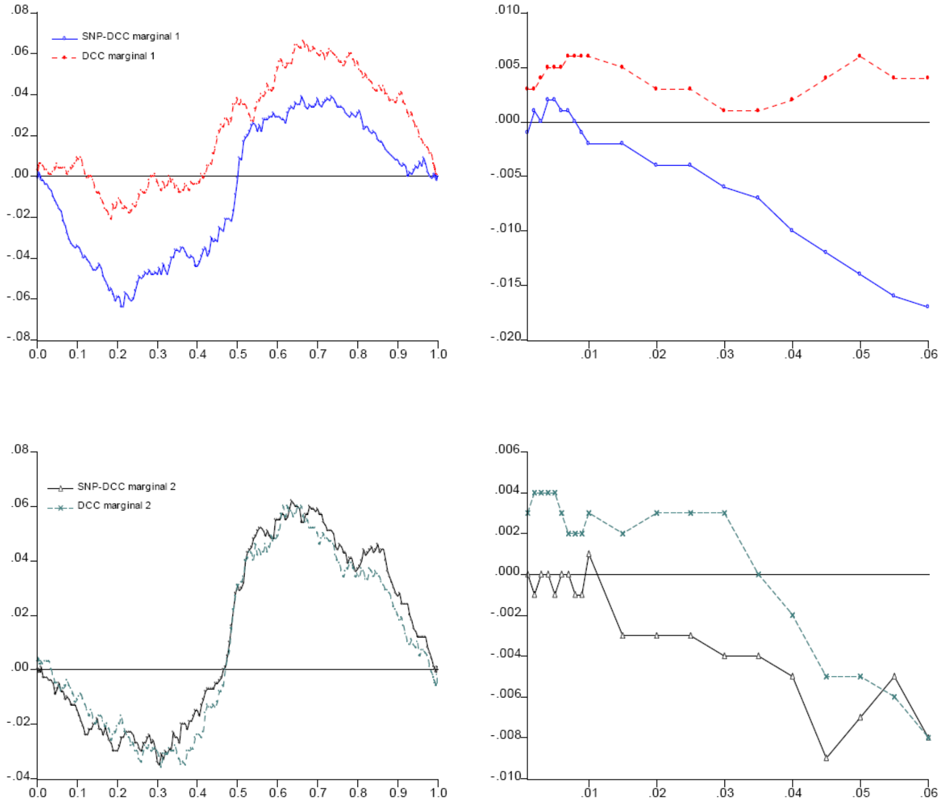
	Portfolio AT&T - JP Morgan		Portfolio FX €/£ - Nasdaq	
	$\overline{\psi}(\cdot,\cdot)$	(t-$stat$)	$\overline{\psi}(\cdot,\cdot)$	(t-$stat$)
SNP marginal 1	.3987		.4194	
DCC marginal 1	.4247	(-4.55)	.4256	(-3.95)
SNP marginal 2	.4271		.4318	
DCC marginal 2	.4379	(-3.82)	.4382	(-2.38)
SNP conditional 1	.4278		.4319	
DCC conditional 1	.4324	(-1.74)	.4391	(-2.30)
SNP conditional 2	.3995		.4195	
DCC conditional 2	.4117	(-3.36)	.4258	(-3.55)

Notes: This table presents the results of average logarithmic scores and statistical tests for one-step-ahead density forecast from SNP-DCC and DCC models. $\overline{\psi}(\cdot,\cdot)$ denotes the average logarithmic scoring rule defined as negatively oriented penalty, so the lower the score the better the model. The table also gathers the results of the Amisano and Giacomini (2007) test for the significance of the difference between the average logarithmic scores: the entries are t-statistics (t-$stat$) for pairwise comparisons between $\overline{\psi}(\cdot,\cdot)$ from the SNP-DCC models versus the DCC models; a negative t-statistic means that the SNP model produces a lower $\overline{\psi}(\cdot,\cdot)$ than its DCC counterpart. Predictions 1,000.

FIGURE 3

P-value discrepancy plots

Portfolio AT&T - JP Morgan



Portfolio AT&T - JP Morgan

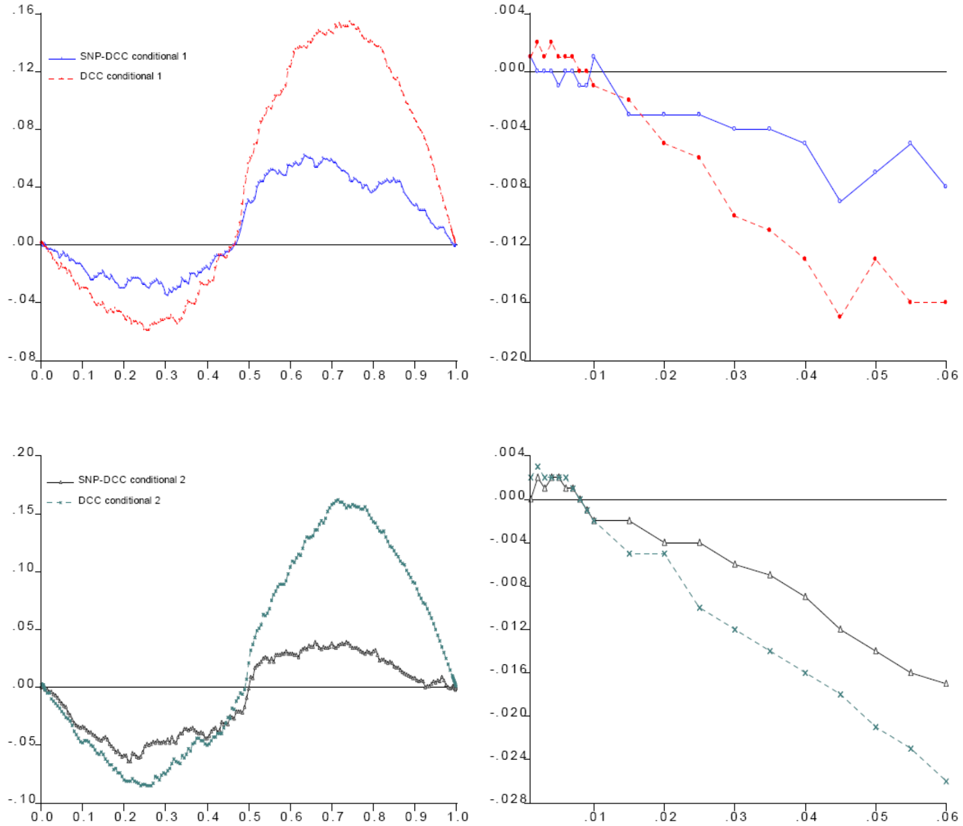
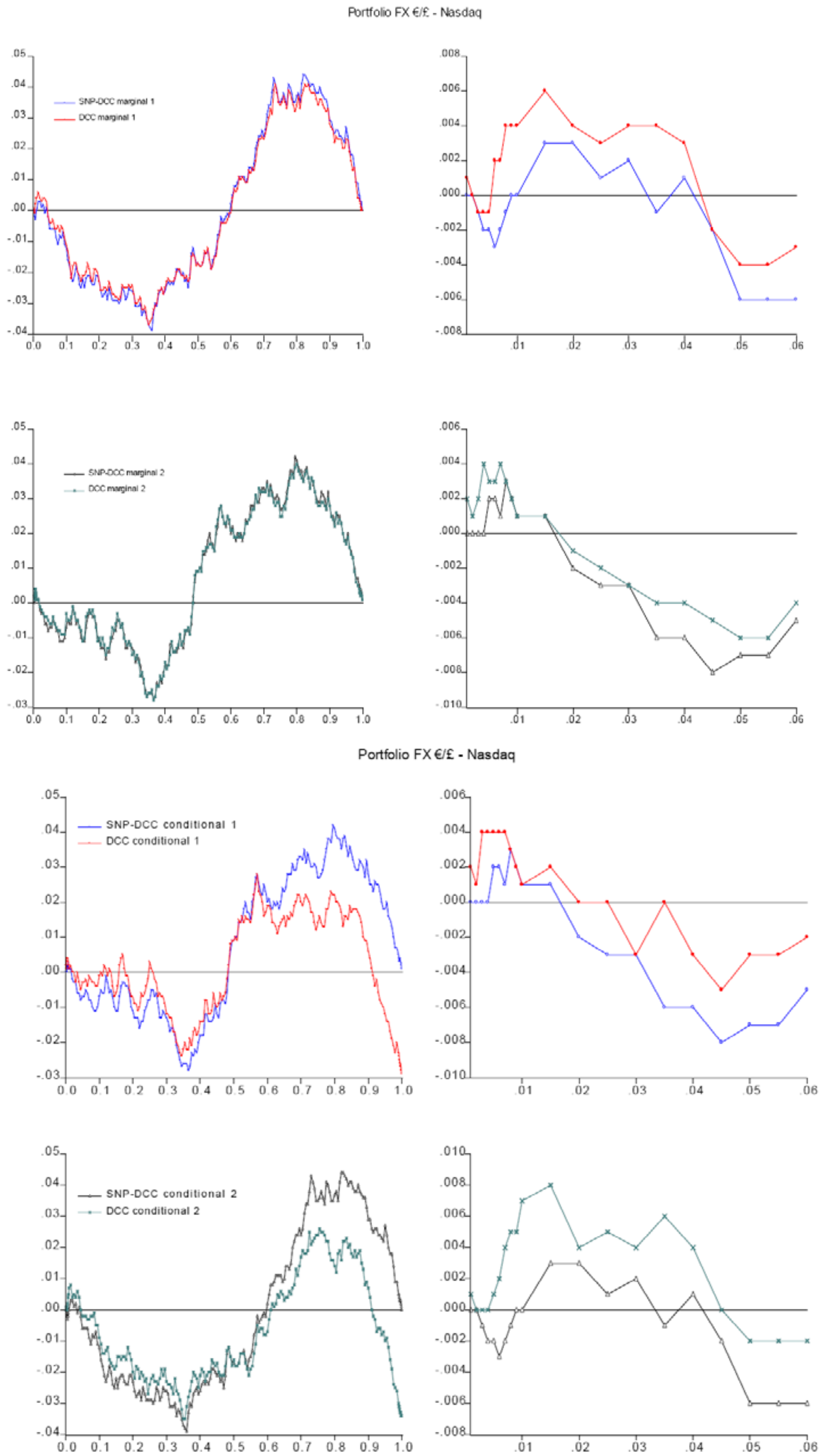


FIGURE 3
(continued)



Notes: P-value discrepancy plots of the PIT empirical cdf of marginal and conditional densities from SNP_{II}-DCC and DCC models. The plots of the 2nd column highlight the models forecasting performance on the left tail of the data empirical distribution. Predictions 1000.

5. Concluding remarks

There exists abundant literature on multivariate volatility models for the time-varying first and second conditional moments of the asset returns distribution. However, not many papers have dealt with the modeling of the full distribution of financial variables. In multivariate analysis, it is usually found that the considered distributions are either not flexible enough to incorporate salient empirical regularities of financial returns (such as heavy tails, possible multimodality, skewness, etc.) or analytically intractable if they incorporate those features. The SNP densities, which are based on Edgeworth and Gram-Charlier expansions, allow to address these topics since, not only they can fit any target density through their general an flexible parametric structure, but also they present an analytical specification that is simple and easy to implement due to the orthogonal structure of Hermite polynomials (i.e., marginals, moments or cdfs can be straightforwardly computed). There have been several attempts to generalize SNP densities to a multivariate context, but the proposed specifications present serious drawbacks, such as ensuring positivity for the full density domain, achieving tractability for large portfolios and incorporating DCC models. This article covers this gap in the literature by proposing a new multivariate positive SNP density that, with a very simple structure, is capable of encompassing as marginals, the alternative univariate SNP used in financial literature. Moreover, the proposed multivariate SNP distribution admits the decomposition of the likelihood function proposed in Engle (2002). We note that this is not trivial for non-Gaussian distributions, e.g., up to the knowledge of the authors, those decompositions are neither possible to other multivariate distributions of this type such as the MES, nor to other non-Normal distributions. The implementation of the Engle's (2002) two-step estimation techniques for SNP distributions helps to solve the known "dimensionality curse" and allows to incorporate dynamic conditional correlations, nesting the (Gaussian)-DCC model in the SNP-DCC.

We compare the empirical performance of two types of multivariate SNP specifications (positive and a non-positive) for modeling the distribution of portfolio returns, in relation to the Gaussian taken as benchmark. Those models were estimated either under CCC or DCC hypotheses. Our results show the superiority of the DCC models in relation to their CCC counterparts. We also find that the considered SNP specifications outperform the Normal, and that the non-positive SNP version seems to provide a better in-sample fit. Nevertheless, since a positive SNP is required in an out-of-sample context, we compared the out-of-sample performance of the (Gaussian)-

DCC and the positive SNP-DCC by using graphical procedures and proper scoring rules and find that the latter provide overall a superior performance (particularly at the distribution tails, i.e. for Value-at-Risk forecasting).

In summary, this paper proposes a new approach to modeling the distribution of financial returns that generalizes the univariate SNP distributions to a multivariate framework guaranteeing the positivity of the density for all values of its parameters. Furthermore, the proposed model avoids the known "dimensionality curse" of the multivariate context, by means of the implementation of the DCC methodology. An empirical application to asset portfolio returns shows that the SNP-DCC model provides an overall better in- and out-of sample performance than the (Gaussian) DCC for full density forecasting.

Appendix

This appendix includes the proofs of the properties of the multivariate SNP densities presented in Section 2. *Proof 1* shows that multivariate SNP densities integrate up to one; *Proof 2*, *Proof 3* and *Proof 4* provide closed forms for the marginal distributions, the moments and the cdf, respectively; *Proof 5* shows how to compute differences between the cdfs under multivariate Normal and SNP densities, and *Proof 6* shows the separability of the log-likelihood for the SNP-DCC model.

Proof 1.

$$\int\cdots\int F^{\varsigma}(X_t)dx_{1t}\cdots dx_{nt} = \frac{1}{n}\int\cdots\int\left\{\prod_{i=1}^{n} g(x_{it})\right\}\left\{\sum_{i=1}^{n}\omega_i^{\varsigma} q_i^{\varsigma}(x_{it})\right\}dx_{1t}\cdots dx_{nt}$$

$$= \frac{1}{n}\sum_{i=1}^{n}\left[\omega_i^{\varsigma}\int g(x_{it})q_i^{\varsigma}(x_{it})dx_{it}\prod_{j=1,j\neq i}^{n}\int g(x_{jt})dx_{jt}\right] = \frac{1}{n}n = 1, \quad \forall\varsigma = \mathrm{I},\mathrm{II}.$$

Proof 2.

$$f_i^{\varsigma}(x_{it}) = \int\cdots\int F^{\varsigma}(X_t)dx_{1t}\cdots dx_{i-1,t}dx_{i+1,t}\cdots dx_{nt}$$

$$= \frac{1}{n}g(x_{it})\omega_i^{\varsigma}q_i^{\varsigma}(x_{it})\prod_{j=1,j\neq i}^{n}\int g(x_{jt})dx_{jt} + \frac{1}{n}g(x_{it})\sum_{j=1,j\neq i}^{n}\left[\prod_{l=1,l\neq i}^{n}\int\omega_l^{\varsigma}g(x_{lt})q_l^{\varsigma}(x_{lt})dx_{lt}\right]$$

$$= \frac{1}{n} g(x_{it}) \omega_i^{\varsigma} q_i^{\varsigma}(x_{it}) + \frac{n-1}{n} g(x_{it}), \quad \forall \varsigma = \mathrm{I}, \mathrm{II}.$$

Furthermore, if ζ=I *(i.e.* $\omega_i^I = 1$*) then*

$$f_i^I(x_{it}) = g(x_{it}) \left[(n-1) + q_i^I(x_{it}) \right] \frac{1}{n} = g(x_{it}) \left[1 + \sum_{s=2}^{n} \frac{\gamma_{is}}{n} H_s(x_{it}) \right].$$

Proof 3.

$$E^I\left[x_{it}^r\right] = \int x_{it}^r f_i^I(x_{it}) dx_{it} = \int x_{it}^r g(x_{it}) dx_{it} + \sum_{s=2}^{m} \frac{\gamma_{is}}{n} \int x_{it}^r H_s(x_{it}) g(x_{it}) dx_{it}$$

$$= \mu_r + \sum_{s=2}^{m} \frac{\gamma_{is}}{n} \sum_{j=0}^{r} c_j \int H_j(x_{it}) H_s(x_{it}) g(x_{it}) dx_{it} = \mu_r + \sum_{j=0}^{r} j! c_j \frac{\gamma_{ij}}{n}.$$

$$E^{II}\left[x_{it}^r\right] = \int x_{it}^r f_i^{II}(x_{it}) dx_{it}$$

$$= \frac{n-1}{n} \int x_{it}^r f_i^I(x_{it}) dx_{it} + \frac{1}{n\omega_i^{II}} \int x_{it}^r g(x_{it}) dx_{it} + \sum_{s=2}^{m} \gamma_{is}^2 \int x_{it}^r H_s(x_{it})^2 g(x_{it}) dx_{it}$$

$$= \left[\frac{n-1}{n} + \frac{1}{n\omega_i^{II}} \right] \mu_r + \frac{1}{n\omega_i^{II}} \sum_{s=2}^{m} \gamma_{is}^2 \sum_{j=0}^{r/2} d_j \int H_j(x_{it})^2 H_s(x_{it})^2 g(x_{it}) dx_{it}$$

$$= \left[\frac{n-1}{n} + \frac{1}{n\omega_i^{II}} \right] \mu_r + \frac{1}{n\omega_i^{II}} \sum_{s=2}^{m} s! \gamma_{is}^2 \sum_{j=0}^{r/2} j! d_j.$$

Proof 4.

$$\Pr\left[x_1 \le a_1, \cdots, x_n \le a_n\right]^{\varsigma} = \frac{1}{n} \int_{-\infty}^{a_1} \cdots \int_{-\infty}^{a_n} \left[\prod_{i=1}^{n} g(x_{it}) \right] \left\{ \sum_{i=1}^{n} \omega_i^{\varsigma} q_i^{\varsigma}(x_{it}) \right\} dx_{1t} \cdots dx_{nt}$$

$$= \frac{1}{n} \sum_{i=1}^{n} \int_{-\infty}^{a_i} \omega_i^{\varsigma} g(x_{it}) q_i^{\varsigma}(x_{it}) dx_{it} \prod_{j=1, j\neq i}^{n} \int_{-\infty}^{a_j} g(x_{jt}) dx_{jt} = \frac{1}{n} \sum_{i=1}^{n} \Psi^{\varsigma}(a_i) \left[\prod_{j=1, j\neq i}^{n} \Phi(a_j) \right], \ \forall \varsigma = \mathrm{I}, \mathrm{II}.$$

Proof 5.

$$\Pr\left[x_1 \le a_1, \cdots, x_n \le a_n\right]^N - \Pr\left[x_1 \le a_1, \cdots, x_n \le a_n\right]^{\varsigma} = \prod_{i=1}^{n} \Phi(a_i) - \frac{1}{n}\sum_{i=1}^{n} \Psi^{\varsigma}(a_i)\left[\prod_{j=1, j\neq i}^{n} \Phi(a_j)\right]$$

$$= \prod_{i=1}^{n} \Phi(a_i) - \frac{1}{n}\sum_{i=1}^{n}\left[\Phi(a_i) - B^{\varsigma}(a_i)\right]\left[\prod_{j=1, j\neq i}^{n} \Phi(a_j)\right]$$

$$= \prod_{i=1}^{n} \Phi(a_i) - \frac{1}{n}\sum_{i=1}^{n}\left[\prod_{j=1}^{n} \Phi(a_i) - B^{\varsigma}(a_i)\prod_{j=1, j\neq i}^{n} \Phi(a_j)\right] = \frac{1}{n}\sum_{i=1}^{n} B^{\varsigma}(a_i)\left[\prod_{j=1, j\neq i}^{n} \Phi(a_j)\right], \ \forall \varsigma = \mathrm{I}, \mathrm{II}.$$

Proof 6.

$$L_{SNP}^{\varsigma}(\Phi, \rho, \gamma) = -\frac{1}{2}\sum_{t=1}^{T}\left[n\log(2\pi) + \ln\left|\Sigma_t\right| + (Y_t - \mu_t)'\Sigma_t^{-1}(Y_t - \mu_t)\right]$$

$$+ \sum_{t=1}^{T}\ln\left[\sum_{i=1}^{n}\omega_i^{\varsigma} q_i^{\varsigma}\left(\Sigma_t^{-1/2}(Y_t - \mu_t)\right)\right] - T\ln(n)$$

$$= -\frac{1}{2}\sum_{t=1}^{T}\left\{n\log(2\pi) + \ln\left|D_t R_t D_t\right| + (Y_t - \mu_t)' D_t^{-1} R_t^{-1} D_t^{-1}(Y_t - \mu_t)\right\}$$

$$+ \sum_{t=1}^{T}\ln\left[\sum_{i=1}^{n}\omega_i^{\varsigma} q_i^{\varsigma}\left(R_t^{-1/2} D_t^{-1}(Y_t - \mu_t)\right)\right] - T\ln(n)$$

$$= -\frac{1}{2}\sum_{t=1}^{T}\left\{n\log(2\pi) + 2\ln\left|D_t\right| + \ln\left|R_t\right| + E_t' R_t^{-1} E_t\right\} + \sum_{t=1}^{T}\ln\left[\sum_{i=1}^{n}\omega_i^{\varsigma} q_i^{\varsigma}\left(R_t^{-1/2} E_t\right)\right] - T\ln(n)$$

$$= -\frac{1}{2}\sum_{t=1}^{T}\left\{n\log(2\pi) + 2\ln\left|D_t\right| + (Y_t - \mu_t)' D_t^{-2}(Y_t - \mu_t) - E_t' E_t + \ln\left|R_t\right| + E_t' R_t^{-1} E_t\right\}$$

$$+ \sum_{t=1}^{T}\ln\left[\sum_{i=1}^{n}\omega_i^{\varsigma} q_i^{\varsigma}\left(R_t^{-1/2} E_t\right)\right] - T\ln(n)$$

$$= -\frac{1}{2}\sum_{t=1}^{T}\sum_{i=1}^{n}\left(\ln(2\pi\sigma_{it}^2) + \frac{(y_{it} - \mu_{it})^2}{\sigma_{it}^2}\right) - \frac{1}{2}\sum_{t=1}^{T}\left(\ln\left|R_t\right| + E_t' R_t^{-1} E_t\right)$$

$$+ \sum_{t=1}^{T}\ln\left[\sum_{i=1}^{n}\omega_i^{\varsigma} q_i^{\varsigma}\left(R_t^{-1/2} E_t\right)\right] + \frac{1}{2}\sum_{i=1}^{T} E_t' E_t - T\ln(n) = L_{MV}(\Phi) + L_{SNP}^{\varsigma}(\Phi, \varphi) + \kappa.$$

References

Aït-Sahalia, Y. & Lo, A. (1998). Nonparametric Estimation of State-Price Densities Implicit in Financial Asset Prices. *Journal of Finance*, 53, 499-547.

Amisano, G. & Giacomini, R. (2007). Comparing Density Forecasts via Weighted Likelihood Ratio Tests. *Journal of Business and Economic Statistics*, 25, 177-190.

Azzalini, A. & Dalla Valle, A. (1996). The Multivariate Skew Normal Distribution. *Biometrika*, 83, 715-726.

Bao, Y., Lee, T-H. & Saltoglu, B. (2007). Comparing Density Forecasts Models. *Journal of Forecasting*, 26, 203-225.

Barton, D. E. & Dennis, K. E. R. (1952). The Conditions under which Gram-Charlier and Edgeworth Curves are Positive Definite and Unimodal. *Biometrika*, 39, 425-427.

Bauwens, L. & Laurent, S. (2005). A New Class of Multivariate Skew Densities, with Application to Generalized Autoregressive Conditional Heteroskedasticity Models. *Journal of Business and Economic Statistics*, 23, 346-354.

Bauwens, L., Laurent, S. & Rombouts, J. V. K. (2005). Multivariate GARCH Models: A Survey. *Journal of Applied Econometrics*, 21, 79-109.

Berndt, E. K., Hall, B. H., Hall, R. E. & Hausman, J. (1974). Estimation and Inference in Nonlinear Structural Models. *Annals of Economics and Social Measurement*, 4, 653-665.

Bollerslev, T. (1990). Modeling the Coherence in Short-Run Nominal Exchange Rates: a Multivariate Generalized ARCH Model. *Review of Economics and Statistics*, 72, 498-505.

Bollerslev, T., Engle, R. & Wooldridge, J. (1988). A Capital Asset Pricing Model with Time-Varying Covariances. *Journal of Political Economy*, 96, 116-131.

Bollerslev, T. & Wooldridge, J. (1992). Quasi Maximum Likelihood Estimation and Inference in Dynamic Models with Time-Varying Covariances. *Econometric Reviews*, 11, 143-172.

Cappiello, L., Engle, R. F. & Sheppard, K. (2006). Asymmetric Dynamics in the Correlations of Global Equity and Bond Returns. *Journal of Financial Econometrics*, 4, 537-572.

Charlier, C. V. (1905). Uber Die Darstellung Willkurlicher Funktionen. *Arvik fur Mathematik Astronomi och Fysik*, 9, 1-13.

Chen, X., Fan, Y. & Tsyrennikov, V. (2006). Efficient Estimation of Semiparametric Multivariate Copula Models. *Journal of the American Statistical Association*, 101, 1228-1240.

Clements, M.P. (2005). *Evaluating Econometric Forecasts of Economic and Financial Variables*. Palgrave Macmillan, New York.

Clements, M.P. & Smith, J. (2000). Evaluating the Forecast Densities of Linear and Non-linear Models: Applications to Output Growth and Unemployment. *Journal of Forecasting*, 19, 255-276.

Cornish, E. & Fisher, R. (1937). Moments and Cumulants in the Specification of Distributions. *Review of International Statistics*, 5, 307-337.

Corrado, C. J. & Su, T. (1996). Skewness and Kurtosis in S&P 500 Index Returns Implied by Option Prices. *Journal of Financial Research*, 19, 175-192.

Christoffersen, P. F. (1998). Evaluating Interval Forecasts. *International Economic Review*, 39, 841-862.

Davidson, R. & MacKinnon, J. G. (1998). Graphical Methods for Investigating the Size and Power of Hypothesis Tests. *The Manchester School of Economic and Social Studies*, 66, 1-26.

Del Brio, E. B., Ñíguez, T. M. & Perote, J. (2009). Gram-Charlier Densities: A Multivariate Approach. *Quantitative Finance*, 9, 855-868.

Diebold, F. X., Gunther, T. A. & Tay, S. A. (1998). Evaluating Density Forecasts with Applications to Financial Risk Management. *International Economic Review*, 39, 863-883.

Diebold, F. X., Tay, S. A. & Wallis, K. F. (1999). Evaluating Density Forecasts of Inflation: The Survey of Professional Forecasters. In *Cointegration, Causality and Forecasting: Festschrift in Honor of C. W. J. Granger*, R. Engle and H. White (eds.), 76-90. Oxford University Press: Oxford.

Diebold, F. X., Hahn, J. & Tay, S. A. (1999). Multivariate Density Forecasts Evaluation and Calibration in Financial Risk Management: High-Frequency Returns of Foreign Exchange. *Review of Economics and Statistics*, 81, 661-673.

Diks, C. & Panchenko, V. & van Dijk, D. (2008). Partial Likelihood-Based Scoring Rules for Evaluating Density Forecasts in Tails. Tinbergen Institute Discussion Paper No. 2008-050/4.

Ding, Z. & Engle, R. F. (2001). Large Scale Conditional Covariance Matrix Modeling, Estimation and Testing. Academia Economic Papers, 29, 157-184.

Edgeworth, F. Y. (1907). On the representation of statistical frequency by series. *Journal of the Royal Statistical Society*, Series A, 80.

Engle, R. F. (2002). Dynamic Conditional Correlation - A Simple Class of Multivariate GARCH Models. *Journal of Business and Economic Statistics*, 20, 339-350.

Engle, R. F. & Kelly, B. (2007). Dynamic Equicorrelation. Proceedings of the 27th International Symposium on Forecasting, New York.

Engle, R. F. & Kroner, K. F. (1995). Multivariate Simultaneous Generalized ARCH. *Econometric Theory*, 11, 122-150.

Engle, R. F., Ng, V. K. & Rothschild, K. F. (1990). Asset Pricing with Factor-ARCH Covariance Structure: Empirical Estimates for Treasure Bills. *Journal of Econometrics*, 45, 213-237.

Engle, R. F. & Sheppard, K. (2001). Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH. NBER Working Paper No. 8554.

Fiorentini, G., Sentana, E. & Calzolari, G. (2003). Maximum Likelihood Estimation and Inference in Multivariate Conditional Heteroskedastic Dynamic Regression Models with Student t Innovations. *Journal of Business and Economic Statistics*, 21, 532-546.

Gallant, R. & Nychka, D. (1987). Seminonparametric Maximum Likelihood Estimation. *Econometrica*, 55, 363-390.

Gallant, R. & Tauchen, G. (1989). Seminonparametric Estimation of Conditionally Constrained Heterogeneous Processes: Asset Pricing Applications. *Econometrica*, 57, 1091-1120.

Geweke, J. & Amisano, G. (2007). Hierarchical Markov Normal Mixture Models with Applications to Financial Asset Returns. European Central Bank Working Paper No. 831.

Geweke, J. & Amisano, G. (2009). Comparing and Evaluating Bayesian Predictive Distributions of Asset Returns. Available from:
http://www.biz.uiowa.edu/faculty/jgeweke/papers/paperD/paper.pdf

Gneiting, T. & Raftery, A. E. (2007). Strictly Proper Scoring Rules, Prediction, and Estimation. *Journal of the American Statistical Association*, 102, 359-378.

Gneiting, T. & Ranjan, R. (2008). Comparing Density Forecasts Using Threshold and Quantile Weighted Scoring Rules. Technical Report no. 533, University of Washington.

Gouriéroux, C. (1997). *ARCH Models and Financial Applications*. Springer-Verlag: New York.

Jondeau, E. & Rockinger, M. (2001). Gram-Charlier Densities. *Journal of Economic Dynamics and Control*, 25, 1457-1483.

Jondeau, E. & Rockinger, M. (2005). Conditional Asset Allocation under Non-Normality: How Costly Is the Mean-Variance Criterion? EFA 2005 Moscow Meetings Discussion Paper.

Jondeau, E., Poon, S. H. & Rockinger, M. (2007). *Financial Modeling Under Non-Gaussian Distributions*. Springer-Verlag: London.

Kendall, M. & Stuart, A. (1977). *The Advanced Theory of Statistics*. Vol. I (4th edn.). Griffin & Co: London.

Kotz, S. & Nadarajah, S. (2004). *Multivariate T-Distributions and Their Applications*. Cambridge University Press: Cambridge.

León, A., Mencía, J. & Sentana, E. (2009). Parametric Properties of Semi-nonparametric Distributions, with Applications to Option Valuation. *Journal of Business and Economic Statistics*, 27, 176-192.

León, A., Rubio, G. & Serna, G. (2005). Autoregressive Conditional Volatility, Skewness and Kurtosis. *Quarterly Review of Economics and Finance*, 45, 599-618.

Malevergne, Y. & Sornette, D. (2004). Multivariate Weibull Distributions for Asset Returns. *Finance Letters*, 2, 16-32.

Marumo, K. & Wolff, R. C. (2007). Expansion Methods Applied to Asset Return Distributions. *Journal of Risk*, 10, 3-24.

Matheson, J. E. & Winkler, R. L. (1976). Scoring Rules for Continuous Probability Distributions. *Management Science*, 22, 1087-1096.

Mauleón, I. & Perote, J. (2000). Testing Densities with Financial Data: An empirical Comparison of the Edgeworth-Sargan Density to the Student's t. *European Journal of Finance*, 6, 225-239.

Mitchell, J. & Hall, S. G. (2005). Evaluating, Comparing and Combining Density Forecasts Using the KLIC with and Application to the Bank of England and NIESR `fan' Charts of Inflation. *Oxford Bulletin of Economics and Statistics*, 67, 995-1033.

Mitchell, J. & Wallis, K. F. (2009). Evaluating Density Forecasts: Forecasts Combinations, Model Mixtures, Calibration and Sharpness. Available from:
http://www.niesr.ac.uk/pdf/MitchellWallisMar09.pdf

Newey, W. K. & McFadden, D. L. (1994). Large Sample Estimation and Hypothesis Testing. In *Handbook of Econometrics* 4, R. F. Engle & D. L. McFadden (eds.), Elsevier Science B.V.

Newey, W. K. & Steigerwald, D. (1997). Asymptotic Bias for Quasi-maximum-likelihood Estimators in Conditional Heteroskedasticity Models. *Econometrica*, 65, 587--599.

Nishiyama, Y. & Robinson, P. M. (2000). Edgeworth Expansions for Semiparametric Averaged Derivatives. *Econometrica*, 68, 931-980.

Ñíguez, T. M. & Perote, J. (2004). Forecasting the Density of Asset Returns. STICERD Econometrics Discussion Paper 479. London School of Economics.

Ñíguez, T. M., Perote, J. & Rubia, A. (2009). Forecasting the Unconditional and Conditional Kurtosis of the Asset Returns Distribution. In *Economic Forecasting* (A. T. Molnar, ed.). Nova Science Publishers Inc.: New York.

Olcay, A. (2005). A New Class of Multivariate Distributions: Scale Mixture of Kotz-Type Distributions. *Statistics and Probability Letters*, 75, 18-28.

Pagan, A. R. (1986). Two Stage and Related Estimators and their Applications. *Review of Economic Studies*, 53, 517-538.

Panagiotelis, A. & Smith, M. (2008). Bayesian Density Forecasts of Intraday Electricity Prices Using Multivariate Skew t Distributions. *International Journal of Forecasting*, 24, 710-727.

Pearson, K. (1933). On a Method of Determining whether a Sample of Size n Supposed to Have Been Drawn from a Parent Population Having a Known Probability Integral Has Probably Been Drawn at Random. *Biometrika*, 25, 379-410.

Perote, J. (2004). The Multivariate Edgeworth-Sargan Density. *Spanish Economic Review*, 6, 77-96.

Rosenblatt, M. (1952). Remarks on a Multivariate Transformation. Annals of *Mathematical Statistics*, 23, 470-472.

Ruiz, E., & Pascual, L. (2002). Bootstrapping Financial Time Series. *Journal of Economic Surveys*, 16, 271-300.

Sargan, J. D. (1975). Gram-Charlier Approximations Applied to t Ratios of k-Class Estimators. *Econometrica*, 43, 327-347.

Sentana, E. & Wadhwani, S. (1992). Feedback Traders and Stock Return Autocorrelations: Evidence from a Century of Daily Data. *Economic Journal* 102, 415-425.

Tay, A. S. & Wallis, K. F. (2000). Density Forecasting: A Survey. *Journal of Forecasting*, 19, 235-254.

Tse, Y. K. & Tsui, A. K. C. (2002). A Multivariate Generalized Autoregressive Conditional Heteroskedasticity Model with Time Varying Correlations. *Journal of Business and Economic Statistics*, 20, 351-362.

Velasco, C. & Robinson, P. M. (2001). Edgeworth Expansions for Spectral Density Estimates and Studentized Simple Mean. *Econometric Theory*, 17, 497-539.

Verhoeven, P. & McAleer, M. (2004). Fat Tails in Financial Volatility Models. *Mathematics and Computers Simulation*, 64, 351-362.

Winkler, R. L. (1967). The Quantification of Judgement: Some Methodological Suggestions. *Journal of the American Statistical Association*, 62, 1105-1120.

FUNDACIÓN DE LAS CAJAS DE AHORROS

DOCUMENTOS DE TRABAJO

Últimos números publicados

159/2000 Participación privada en la construcción y explotación de carreteras de peaje
Ginés de Rus, Manuel Romero y Lourdes Trujillo

160/2000 Errores y posibles soluciones en la aplicación del *Value at Risk*
Mariano González Sánchez

161/2000 Tax neutrality on saving assets. The spahish case before and after the tax reform
Cristina Ruza y de Paz-Curbera

162/2000 Private rates of return to human capital in Spain: new evidence
F. Barceinas, J. Oliver-Alonso, J.L. Raymond y J.L. Roig-Sabaté

163/2000 El control interno del riesgo. Una propuesta de sistema de límites riesgo neutral
Mariano González Sánchez

164/2001 La evolución de las políticas de gasto de las Administraciones Públicas en los años 90
Alfonso Utrilla de la Hoz y Carmen Pérez Esparrells

165/2001 Bank cost efficiency and output specification
Emili Tortosa-Ausina

166/2001 Recent trends in Spanish income distribution: A robust picture of falling income inequality
Josep Oliver-Alonso, Xavier Ramos y José Luis Raymond-Bara

167/2001 Efectos redistributivos y sobre el bienestar social del tratamiento de las cargas familiares en el nuevo IRPF
Nuria Badenes Plá, Julio López Laborda, Jorge Onrubia Fernández

168/2001 The Effects of Bank Debt on Financial Structure of Small and Medium Firms in some European Countries
Mónica Melle-Hernández

169/2001 La política de cohesión de la UE ampliada: la perspectiva de España
Ismael Sanz Labrador

170/2002 Riesgo de liquidez de Mercado
Mariano González Sánchez

171/2002 Los costes de administración para el afiliado en los sistemas de pensiones basados en cuentas de capitalización individual: medida y comparación internacional.
José Enrique Devesa Carpio, Rosa Rodríguez Barrera, Carlos Vidal Meliá

172/2002 La encuesta continua de presupuestos familiares (1985-1996): descripción, representatividad y propuestas de metodología para la explotación de la información de los ingresos y el gasto.
Llorenc Pou, Joaquín Alegre

173/2002 Modelos paramétricos y no paramétricos en problemas de concesión de tarjetas de credito.
Rosa Puertas, María Bonilla, Ignacio Olmeda

174/2002 Mercado único, comercio intra-industrial y costes de ajuste en las manufacturas españolas.
José Vicente Blanes Cristóbal

175/2003 La Administración tributaria en España. Un análisis de la gestión a través de los ingresos y de los gastos.
Juan de Dios Jiménez Aguilera, Pedro Enrique Barrilao González

176/2003 The Falling Share of Cash Payments in Spain.
Santiago Carbó Valverde, Rafael López del Paso, David B. Humphrey
Publicado en "Moneda y Crédito" nº 217, pags. 167-189.

177/2003 Effects of ATMs and Electronic Payments on Banking Costs: The Spanish Case.
Santiago Carbó Valverde, Rafael López del Paso, David B. Humphrey

178/2003 Factors explaining the interest margin in the banking sectors of the European Union.
Joaquín Maudos y Juan Fernández Guevara

179/2003 Los planes de stock options para directivos y consejeros y su valoración por el mercado de valores en España.
Mónica Melle Hernández

180/2003 Ownership and Performance in Europe and US Banking – A comparison of Commercial, Co-operative & Savings Banks.
Yener Altunbas, Santiago Carbó y Phil Molyneux

181/2003 The Euro effect on the integration of the European stock markets.
Mónica Melle Hernández

182/2004 In search of complementarity in the innovation strategy: international R&D and external knowledge acquisition.
Bruno Cassiman, Reinhilde Veugelers

183/2004 Fijación de precios en el sector público: una aplicación para el servicio municipal de suministro de agua.
Mª Ángeles García Valiñas

184/2004 Estimación de la economía sumergida es España: un modelo estructural de variables latentes.
Ángel Alañón Pardo, Miguel Gómez de Antonio

185/2004 Causas políticas y consecuencias sociales de la corrupción.
Joan Oriol Prats Cabrera

186/2004 Loan bankers' decisions and sensitivity to the audit report using the belief revision model.
Andrés Guiral Contreras and José A. Gonzalo Angulo

187/2004 El modelo de Black, Derman y Toy en la práctica. Aplicación al mercado español.
Marta Tolentino García-Abadillo y Antonio Díaz Pérez

188/2004 Does market competition make banks perform well?.
Mónica Melle

189/2004 Efficiency differences among banks: external, technical, internal, and managerial
Santiago Carbó Valverde, David B. Humphrey y Rafael López del Paso

190/2004 Una aproximación al análisis de los costes de la esquizofrenia en españa: los modelos jerárquicos bayesianos
F. J. Vázquez-Polo, M. A. Negrín, J. M. Cavasés, E. Sánchez y grupo RIRAG

191/2004 Environmental proactivity and business performance: an empirical analysis
Javier González-Benito y Óscar González-Benito

192/2004 Economic risk to beneficiaries in notional defined contribution accounts (NDCs)
Carlos Vidal-Meliá, Inmaculada Domínguez-Fabian y José Enrique Devesa-Carpio

193/2004 Sources of efficiency gains in port reform: non parametric malmquist decomposition tfp index for Mexico
Antonio Estache, Beatriz Tovar de la Fé y Lourdes Trujillo

194/2004 Persistencia de resultados en los fondos de inversión españoles
Alfredo Ciriaco Fernández y Rafael Santamaría Aquilué

195/2005 El modelo de revisión de creencias como aproximación psicológica a la formación del juicio del auditor sobre la gestión continuada
Andrés Guiral Contreras y Francisco Esteso Sánchez

196/2005 La nueva financiación sanitaria en España: descentralización y prospectiva
David Cantarero Prieto

197/2005 A cointegration analysis of the Long-Run supply response of Spanish agriculture to the common agricultural policy
José A. Mendez, Ricardo Mora y Carlos San Juan

198/2005 ¿Refleja la estructura temporal de los tipos de interés del mercado español preferencia por la liquidez?
Magdalena Massot Perelló y Juan M. Nave

199/2005 Análisis de impacto de los Fondos Estructurales Europeos recibidos por una economía regional: Un enfoque a través de Matrices de Contabilidad Social
M. Carmen Lima y M. Alejandro Cardenete

200/2005 Does the development of non-cash payments affect monetary policy transmission?
Santiago Carbó Valverde y Rafael López del Paso

201/2005 Firm and time varying technical and allocative efficiency: an application for port cargo handling firms
Ana Rodríguez-Álvarez, Beatriz Tovar de la Fe y Lourdes Trujillo

202/2005 Contractual complexity in strategic alliances
Jeffrey J. Reuer y Africa Ariño

203/2005 Factores determinantes de la evolución del empleo en las empresas adquiridas por opa
Nuria Alcalde Fradejas y Inés Pérez-Soba Aguilar

204/2005 Nonlinear Forecasting in Economics: a comparison between Comprehension Approach versus Learning Approach. An Application to Spanish Time Series
Elena Olmedo, Juan M. Valderas, Ricardo Gimeno and Lorenzo Escot

205/2005 Precio de la tierra con presión urbana: un modelo para España
Esther Decimavilla, Carlos San Juan y Stefan Sperlich

206/2005 Interregional migration in Spain: a semiparametric analysis
Adolfo Maza y José Villaverde

207/2005 Productivity growth in European banking
Carmen Murillo-Melchor, José Manuel Pastor y Emili Tortosa-Ausina

208/2005 Explaining Bank Cost Efficiency in Europe: Environmental and Productivity Influences.
Santiago Carbó Valverde, David B. Humphrey y Rafael López del Paso

209/2005 La elasticidad de sustitución intertemporal con preferencias no separables intratemporalmente: los casos de Alemania, España y Francia.
Elena Márquez de la Cruz, Ana R. Martínez Cañete y Inés Pérez-Soba Aguilar

210/2005 Contribución de los efectos tamaño, book-to-market y momentum a la valoración de activos: el caso español.
Begoña Font-Belaire y Alfredo Juan Grau-Grau

211/2005 Permanent income, convergence and inequality among countries
José M. Pastor and Lorenzo Serrano

212/2005 The Latin Model of Welfare: Do 'Insertion Contracts' Reduce Long-Term Dependence?
Luis Ayala and Magdalena Rodríguez

213/2005 The effect of geographic expansion on the productivity of Spanish savings banks
Manuel Illueca, José M. Pastor and Emili Tortosa-Ausina

214/2005 Dynamic network interconnection under consumer switching costs
Ángel Luis López Rodríguez

215/2005 La influencia del entorno socioeconómico en la realización de estudios universitarios: una aproximación al caso español en la década de los noventa
Marta Rahona López

216/2005 The valuation of spanish ipos: efficiency analysis
Susana Álvarez Otero

217/2005 On the generation of a regular multi-input multi-output technology using parametric output distance functions
Sergio Perelman and Daniel Santin

218/2005 La gobernanza de los procesos parlamentarios: la organización industrial del congreso de los diputados en España
Gonzalo Caballero Miguez

219/2005 Determinants of bank market structure: Efficiency and political economy variables
Francisco González

220/2005 Agresividad de las órdenes introducidas en el mercado español: estrategias, determinantes y medidas de performance
David Abad Díaz

221/2005 Tendencia post-anuncio de resultados contables: evidencia para el mercado español
Carlos Forner Rodríguez, Joaquín Marhuenda Fructuoso y Sonia Sanabria García

222/2005 Human capital accumulation and geography: empirical evidence in the European Union
Jesús López-Rodríguez, J. Andrés Faíña y Jose Lopez Rodríguez

223/2005 Auditors' Forecasting in Going Concern Decisions: Framing, Confidence and Information Processing
Waymond Rodgers and Andrés Guiral

224/2005 The effect of Structural Fund spending on the Galician region: an assessment of the 1994-1999 and 2000-2006 Galician CSFs
José Ramón Cancelo de la Torre, J. Andrés Faíña and Jesús López-Rodríguez

225/2005 The effects of ownership structure and board composition on the audit committee activity: Spanish evidence
Carlos Fernández Méndez and Rubén Arrondo García

226/2005 Cross-country determinants of bank income smoothing by managing loan loss provisions
Ana Rosa Fonseca and Francisco González

227/2005 Incumplimiento fiscal en el irpf (1993-2000): un análisis de sus factores determinantes
Alejandro Estellér Moré

228/2005 Region versus Industry effects: volatility transmission
Pilar Soriano Felipe and Francisco J. Climent Diranzo

229/2005 Concurrent Engineering: The Moderating Effect Of Uncertainty On New Product Development Success
Daniel Vázquez-Bustelo and Sandra Valle

230/2005 On zero lower bound traps: a framework for the analysis of monetary policy in the 'age' of central banks
Alfonso Palacio-Vera

231/2005 Reconciling Sustainability and Discounting in Cost Benefit Analysis: a methodological proposal
M. Carmen Almansa Sáez and Javier Calatrava Requena

232/2005 Can The Excess Of Liquidity Affect The Effectiveness Of The European Monetary Policy?
Santiago Carbó Valverde and Rafael López del Paso

233/2005 Inheritance Taxes In The Eu Fiscal Systems: The Present Situation And Future Perspectives.
Miguel Angel Barberán Lahuerta

234/2006 Bank Ownership And Informativeness Of Earnings.
Víctor M. González

235/2006 Developing A Predictive Method: A Comparative Study Of The Partial Least Squares Vs Maximum Likelihood Techniques.
Waymond Rodgers, Paul Pavlou and Andres Guiral.

236/2006 Using Compromise Programming for Macroeconomic Policy Making in a General Equilibrium Framework: Theory and Application to the Spanish Economy.
Francisco J. André, M. Alejandro Cardenete y Carlos Romero.

237/2006 Bank Market Power And Sme Financing Constraints.
Santiago Carbó-Valverde, Francisco Rodríguez-Fernández y Gregory F. Udell.

238/2006 Trade Effects Of Monetary Agreements: Evidence For Oecd Countries.
Salvador Gil-Pareja, Rafael Llorca-Vivero y José Antonio Martínez-Serrano.

239/2006 The Quality Of Institutions: A Genetic Programming Approach.
Marcos Álvarez-Díaz y Gonzalo Caballero Miguez.

240/2006 La interacción entre el éxito competitivo y las condiciones del mercado doméstico como determinantes de la decisión de exportación en las Pymes.
Francisco García Pérez.

241/2006 Una estimación de la depreciación del capital humano por sectores, por ocupación y en el tiempo.
Inés P. Murillo.

242/2006 Consumption And Leisure Externalities, Economic Growth And Equilibrium Efficiency.
Manuel A. Gómez.

243/2006 Measuring efficiency in education: an analysis of different approaches for incorporating non-discretionary inputs.
Jose Manuel Cordero-Ferrera, Francisco Pedraja-Chaparro y Javier Salinas-Jiménez

244/2006 Did The European Exchange-Rate Mechanism Contribute To The Integration Of Peripheral Countries?.
Salvador Gil-Pareja, Rafael Llorca-Vivero y José Antonio Martínez-Serrano

245/2006 Intergenerational Health Mobility: An Empirical Approach Based On The Echp.
Marta Pascual and David Cantarero

246/2006 Measurement and analysis of the Spanish Stock Exchange using the Lyapunov exponent with digital technology.
Salvador Rojí Ferrari and Ana Gonzalez Marcos

247/2006 Testing For Structural Breaks In Variance Withadditive Outliers And Measurement Errors.
Paulo M.M. Rodrigues and Antonio Rubia

248/2006 The Cost Of Market Power In Banking: Social Welfare Loss Vs. Cost Inefficiency.
Joaquín Maudos and Juan Fernández de Guevara

249/2006 Elasticidades de largo plazo de la demanda de vivienda: evidencia para España (1885-2000).
Desiderio Romero Jordán, José Félix Sanz Sanz y César Pérez López

250/2006 Regional Income Disparities in Europe: What role for location?.
Jesús López-Rodríguez and J. Andrés Faíña

251/2006 Funciones abreviadas de bienestar social: Una forma sencilla de simultanear la medición de la eficiencia y la equidad de las políticas de gasto público.
Nuria Badenes Plá y Daniel Santín González

252/2006 "The momentum effect in the Spanish stock market: Omitted risk factors or investor behaviour?".
Luis Muga and Rafael Santamaría

253/2006 Dinámica de precios en el mercado español de gasolina: un equilibrio de colusión tácita.
Jordi Perdiguero García

254/2006 Desigualdad regional en España: renta permanente versus renta corriente.
José M.Pastor, Empar Pons y Lorenzo Serrano

255/2006 Environmental implications of organic food preferences: an application of the impure public goods model.
Ana Maria Aldanondo-Ochoa y Carmen Almansa-Sáez

256/2006 Family tax credits versus family allowances when labour supply matters: Evidence for Spain.
José Felix Sanz-Sanz, Desiderio Romero-Jordán y Santiago Álvarez-García

257/2006 La internacionalización de la empresa manufacturera española: efectos del capital humano genérico y específico.
José López Rodríguez

258/2006 Evaluación de las migraciones interregionales en España, 1996-2004.
María Martínez Torres

259/2006 Efficiency and market power in Spanish banking.
Rolf Färe, Shawna Grosskopf y Emili Tortosa-Ausina.

260/2006 Asimetrías en volatilidad, beta y contagios entre las empresas grandes y pequeñas cotizadas en la bolsa española.
Helena Chuliá y Hipòlit Torró.

261/2006 Birth Replacement Ratios: New Measures of Period Population Replacement.
José Antonio Ortega.

262/2006 Accidentes de tráfico, víctimas mortales y consumo de alcohol.
José Mª Arranz y Ana I. Gil.

263/2006 Análisis de la Presencia de la Mujer en los Consejos de Administración de las Mil Mayores Empresas Españolas.
Ruth Mateos de Cabo, Lorenzo Escot Mangas y Ricardo Gimeno Nogués.

264/2006 Crisis y Reforma del Pacto de Estabilidad y Crecimiento. Las Limitaciones de la Política Económica en Europa.
Ignacio Álvarez Peralta.

265/2006 Have Child Tax Allowances Affected Family Size? A Microdata Study For Spain (1996-2000).
Jaime Vallés-Giménez y Anabel Zárate-Marco.

266/2006 Health Human Capital And The Shift From Foraging To Farming.
Paolo Rungo.

267/2006 Financiación Autonómica y Política de la Competencia: El Mercado de Gasolina en Canarias.
Juan Luis Jiménez y Jordi Perdiguero.

268/2006 El cumplimiento del Protocolo de Kyoto para los hogares españoles: el papel de la imposición sobre la energía.
Desiderio Romero-Jordán y José Félix Sanz-Sanz.

269/2006 Banking competition, financial dependence and economic growth
Joaquín Maudos y Juan Fernández de Guevara

270/2006 Efficiency, subsidies and environmental adaptation of animal farming under CAP
Werner Kleinhanß, Carmen Murillo, Carlos San Juan y Stefan Sperlich

271/2006 Interest Groups, Incentives to Cooperation and Decision-Making Process in the European Union
A. Garcia-Lorenzo y Jesús López-Rodríguez

272/2006 Riesgo asimétrico y estrategias de momentum en el mercado de valores español
Luis Muga y Rafael Santamaría

273/2006 Valoración de capital-riesgo en proyectos de base tecnológica e innovadora a través de la teoría de opciones reales
Gracia Rubio Martín

274/2006 Capital stock and unemployment: searching for the missing link
Ana Rosa Martínez-Cañete, Elena Márquez de la Cruz, Alfonso Palacio-Vera and Inés Pérez-Soba Aguilar

275/2006 Study of the influence of the voters' political culture on vote decision through the simulation of a political competition problem in Spain
Sagrario Lantarón, Isabel Lillo, Mª Dolores López and Javier Rodrigo

276/2006 Investment and growth in Europe during the Golden Age
Antonio Cubel and Mª Teresa Sanchis

277/2006 Efectos de vincular la pensión pública a la inversión en cantidad y calidad de hijos en un modelo de equilibrio general
Robert Meneu Gaya

278/2006 El consumo y la valoración de activos
Elena Márquez y Belén Nieto

279/2006 Economic growth and currency crisis: A real exchange rate entropic approach
David Matesanz Gómez y Guillermo J. Ortega

280/2006 Three measures of returns to education: An illustration for the case of Spain
María Arrazola y José de Hevia

281/2006 Composition of Firms versus Composition of Jobs
Antoni Cunyat

282/2006 La vocación internacional de un holding tranviario belga: la Compagnie Mutuelle de Tramways, 1895-1918
Alberte Martínez López

283/2006 Una visión panorámica de las entidades de crédito en España en la última década.
Constantino García Ramos

284/2006 Foreign Capital and Business Strategies: a comparative analysis of urban transport in Madrid and Barcelona, 1871-1925
Alberte Martínez López

285/2006 Los intereses belgas en la red ferroviaria catalana, 1890-1936
Alberte Martínez López

286/2006 The Governance of Quality: The Case of the Agrifood Brand Names
Marta Fernández Barcala, Manuel González-Díaz y Emmanuel Raynaud

287/2006 Modelling the role of health status in the transition out of malthusian equilibrium
Paolo Rungo, Luis Currais and Berta Rivera

288/2006 Industrial Effects of Climate Change Policies through the EU Emissions Trading Scheme
Xavier Labandeira and Miguel Rodríguez

289/2006 Globalisation and the Composition of Government Spending: An analysis for OECD countries
Norman Gemmell, Richard Kneller and Ismael Sanz

290/2006 La producción de energía eléctrica en España: Análisis económico de la actividad tras la liberalización del Sector Eléctrico
Fernando Hernández Martínez

291/2006 Further considerations on the link between adjustment costs and the productivity of R&D investment: evidence for Spain
Desiderio Romero-Jordán, José Félix Sanz-Sanz and Inmaculada Álvarez-Ayuso

292/2006 Una teoría sobre la contribución de la función de compras al rendimiento empresarial
Javier González Benito

293/2006 Agility drivers, enablers and outcomes: empirical test of an integrated agile manufacturing model
Daniel Vázquez-Bustelo, Lucía Avella and Esteban Fernández

294/2006 Testing the parametric vs the semiparametric generalized mixed effects models
María José Lombardía and Stefan Sperlich

295/2006 Nonlinear dynamics in energy futures
Mariano Matilla-García

296/2006 Estimating Spatial Models By Generalized Maximum Entropy Or How To Get Rid Of W
Esteban Fernández Vázquez, Matías Mayor Fernández and Jorge Rodriguez-Valez

297/2006 Optimización fiscal en las transmisiones lucrativas: análisis metodológico
Félix Domínguez Barrero

298/2006 La situación actual de la banca online en España
Francisco José Climent Diranzo y Alexandre Momparler Pechuán

299/2006 Estrategia competitiva y rendimiento del negocio: el papel mediador de la estrategia y las capacidades productivas
Javier González Benito y Isabel Suárez González

300/2006 A Parametric Model to Estimate Risk in a Fixed Income Portfolio
Pilar Abad and Sonia Benito

301/2007 Análisis Empírico de las Preferencias Sociales Respecto del Gasto en Obra Social de las Cajas de Ahorros
Alejandro Esteller-Moré, Jonathan Jorba Jiménez y Albert Solé-Ollé

302/2007 Assessing the enlargement and deepening of regional trading blocs: The European Union case
Salvador Gil-Pareja, Rafael Llorca-Vivero y José Antonio Martínez-Serrano

303/2007 ¿Es la Franquicia un Medio de Financiación?: Evidencia para el Caso Español
Vanesa Solís Rodríguez y Manuel González Díaz

304/2007 On the Finite-Sample Biases in Nonparametric Testing for Variance Constancy
Paulo M.M. Rodrigues and Antonio Rubia

305/2007 Spain is Different: Relative Wages 1989-98
José Antonio Carrasco Gallego

306/2007 Poverty reduction and SAM multipliers: An evaluation of public policies in a regional framework
Francisco Javier De Miguel-Vélez y Jesús Pérez-Mayo

307/2007 La Eficiencia en la Gestión del Riesgo de Crédito en las Cajas de Ahorro
Marcelino Martínez Cabrera

308/2007 Optimal environmental policy in transport: unintended effects on consumers' generalized price
M. Pilar Socorro and Ofelia Betancor

309/2007 Agricultural Productivity in the European Regions: Trends and Explanatory Factors
Roberto Ezcurra, Belen Iráizoz, Pedro Pascual and Manuel Rapún

310/2007 Long-run Regional Population Divergence and Modern Economic Growth in Europe: a Case Study of Spain
María Isabel Ayuda, Fernando Collantes and Vicente Pinilla

311/2007 Financial Information effects on the measurement of Commercial Banks' Efficiency
Borja Amor, María T. Tascón and José L. Fanjul

312/2007 Neutralidad e incentivos de las inversiones financieras en el nuevo IRPF
Félix Domínguez Barrero

313/2007 The Effects of Corporate Social Responsibility Perceptions on The Valuation of Common Stock
Waymond Rodgers , Helen Choy and Andres Guiral-Contreras

314/2007 Country Creditor Rights, Information Sharing and Commercial Banks' Profitability Persistence across the world
Borja Amor, María T. Tascón and José L. Fanjul

315/2007 ¿Es Relevante el Déficit Corriente en una Unión Monetaria? El Caso Español
Javier Blanco González y Ignacio del Rosal Fernández

316/2007 The Impact of Credit Rating Announcements on Spanish Corporate Fixed Income Performance: Returns, Yields and Liquidity
Pilar Abad, Antonio Díaz and M. Dolores Robles

317/2007 Indicadores de Lealtad al Establecimiento y Formato Comercial Basados en la Distribución del Presupuesto
Cesar Augusto Bustos Reyes y Óscar González Benito

318/2007 Migrants and Market Potential in Spain over The XXth Century: A Test Of The New Economic Geography
Daniel A. Tirado, Jordi Pons, Elisenda Paluzie and Javier Silvestre

319/2007 El Impacto del Coste de Oportunidad de la Actividad Emprendedora en la Intención de los Ciudadanos Europeos de Crear Empresas
Luis Miguel Zapico Aldeano

320/2007 Los belgas y los ferrocarriles de vía estrecha en España, 1887-1936
Alberte Martínez López

321/2007 Competición política bipartidista. Estudio geométrico del equilibrio en un caso ponderado
Isabel Lillo, Mª Dolores López y Javier Rodrigo

322/2007 Human resource management and environment management systems: an empirical study
Mª Concepción López Fernández, Ana Mª Serrano Bedia and Gema García Piqueres

323/2007 Wood and industrialization. evidence and hypotheses from the case of Spain, 1860-1935.
Iñaki Iriarte-Goñi and María Isabel Ayuda Bosque

324/2007 New evidence on long-run monetary neutrality.
J. Cunado, L.A. Gil-Alana and F. Perez de Gracia

325/2007 Monetary policy and structural changes in the volatility of us interest rates.
Juncal Cuñado, Javier Gomez Biscarri and Fernando Perez de Gracia

326/2007 The productivity effects of intrafirm diffusion.
Lucio Fuentelsaz, Jaime Gómez and Sergio Palomas

327/2007 Unemployment duration, layoffs and competing risks.
J.M. Arranz, C. García-Serrano and L. Toharia

328/2007 El grado de cobertura del gasto público en España respecto a la UE-15
Nuria Rueda, Begoña Barruso, Carmen Calderón y Mª del Mar Herrador

329/2007 The Impact of Direct Subsidies in Spain before and after the CAP'92 Reform
Carmen Murillo, Carlos San Juan and Stefan Sperlich

330/2007 Determinants of post-privatisation performance of Spanish divested firms
Laura Cabeza García and Silvia Gómez Ansón

331/2007 ¿Por qué deciden diversificar las empresas españolas? Razones oportunistas versus razones económicas
Almudena Martínez Campillo

332/2007 Dynamical Hierarchical Tree in Currency Markets
Juan Gabriel Brida, David Matesanz Gómez and Wiston Adrián Risso

333/2007 Los determinantes sociodemográficos del gasto sanitario. Análisis con microdatos individuales
Ana María Angulo, Ramón Barberán, Pilar Egea y Jesús Mur

334/2007 Why do companies go private? The Spanish case
Inés Pérez-Soba Aguilar

335/2007 The use of gis to study transport for disabled people
Verónica Cañal Fernández

336/2007 The long run consequences of M&A: An empirical application
Cristina Bernad, Lucio Fuentelsaz and Jaime Gómez

337/2007 Las clasificaciones de materias en economía: principios para el desarrollo de una nueva clasificación
Valentín Edo Hernández

338/2007 Reforming Taxes and Improving Health: A Revenue-Neutral Tax Reform to Eliminate Medical and Pharmaceutical VAT
Santiago Álvarez-García, Carlos Pestana Barros y Juan Prieto-Rodriguez

339/2007 Impacts of an iron and steel plant on residential property values
Celia Bilbao-Terol

340/2007 Firm size and capital structure: Evidence using dynamic panel data
Víctor M. González and Francisco González

341/2007 ¿Cómo organizar una cadena hotelera? La elección de la forma de gobierno
Marta Fernández Barcala y Manuel González Díaz

342/2007 Análisis de los efectos de la decisión de diversificar: un contraste del marco teórico "Agencia-Stewardship"
Almudena Martínez Campillo y Roberto Fernández Gago

343/2007 Selecting portfolios given multiple eurostoxx-based uncertainty scenarios: a stochastic goal programming approach from fuzzy betas
Enrique Ballestero, Blanca Pérez-Gladish, Mar Arenas-Parra and Amelia Bilbao-Terol

344/2007 "El bienestar de los inmigrantes y los factores implicados en la decisión de emigrar"
Anastasia Hernández Alemán y Carmelo J. León

345/2007 Governance Decisions in the R&D Process: An Integrative Framework Based on TCT and Knowledge View of The Firm.
Andrea Martínez-Noya and Esteban García-Canal

346/2007 Diferencias salariales entre empresas públicas y privadas. El caso español
Begoña Cueto y Nuria Sánchez- Sánchez

347/2007 Effects of Fiscal Treatments of Second Home Ownership on Renting Supply
Celia Bilbao Terol and Juan Prieto Rodríguez

348/2007 Auditors' ethical dilemmas in the going concern evaluation
Andres Guiral, Waymond Rodgers, Emiliano Ruiz and Jose A. Gonzalo

349/2007 Convergencia en capital humano en España. Un análisis regional para el periodo 1970-2004
Susana Morales Sequera y Carmen Pérez Esparrells

350/2007 Socially responsible investment: mutual funds portfolio selection using fuzzy multiobjective programming
Blanca Mª Pérez-Gladish, Mar Arenas-Parra , Amelia Bilbao-Terol and Mª Victoria Rodríguez-Uría

351/2007 Persistencia del resultado contable y sus componentes: implicaciones de la medida de ajustes por devengo
Raúl Iñiguez Sánchez y Francisco Poveda Fuentes

352/2007 Wage Inequality and Globalisation: What can we Learn from the Past? A General Equilibrium Approach
Concha Betrán, Javier Ferri and Maria A. Pons

353/2007 Eficacia de los incentivos fiscales a la inversión en I+D en España en los años noventa
Desiderio Romero Jordán y José Félix Sanz Sanz

354/2007 Convergencia regional en renta y bienestar en España
Robert Meneu Gaya

355/2007 Tributación ambiental: Estado de la Cuestión y Experiencia en España
Ana Carrera Poncela

356/2007 Salient features of dependence in daily us stock market indices
Luis A. Gil-Alana, Juncal Cuñado and Fernando Pérez de Gracia

357/2007 La educación superior: ¿un gasto o una inversión rentable para el sector público?
Inés P. Murillo y Francisco Pedraja

358/2007 Effects of a reduction of working hours on a model with job creation and job destruction
Emilio Domínguez, Miren Ullibarri y Idoya Zabaleta

359/2007 Stock split size, signaling and earnings management: Evidence from the Spanish market
José Yagüe, J. Carlos Gómez-Sala and Francisco Poveda-Fuentes

360/2007 Modelización de las expectativas y estrategias de inversión en mercados de derivados
Begoña Font-Belaire

361/2008 Trade in capital goods during the golden age, 1953-1973
Mª Teresa Sanchis and Antonio Cubel

362/2008 El capital económico por riesgo operacional: una aplicación del modelo de distribución de pérdidas
Enrique José Jiménez Rodríguez y José Manuel Feria Domínguez

363/2008 The drivers of effectiveness in competition policy
Joan-Ramon Borrell and Juan-Luis Jiménez

364/2008 Corporate governance structure and board of directors remuneration policies: evidence from Spain
Carlos Fernández Méndez, Rubén Arrondo García and Enrique Fernández Rodríguez

365/2008 Beyond the disciplinary role of governance: how boards and donors add value to Spanish foundations
Pablo De Andrés Alonso, Valentín Azofra Palenzuela y M. Elena Romero Merino

366/2008 Complejidad y perfeccionamiento contractual para la contención del oportunismo en los acuerdos de franquicia
Vanesa Solís Rodríguez y Manuel González Díaz

367/2008 Inestabilidad y convergencia entre las regiones europeas
Jesús Mur, Fernando López y Ana Angulo

368/2008 Análisis espacial del cierre de explotaciones agrarias
Ana Aldanondo Ochoa, Carmen Almansa Sáez y Valero Casanovas Oliva

369/2008 Cross-Country Efficiency Comparison between Italian and Spanish Public Universities in the period 2000-2005
Tommaso Agasisti and Carmen Pérez Esparrells

370/2008 El desarrollo de la sociedad de la información en España: un análisis por comunidades autónomas
María Concepción García Jiménez y José Luis Gómez Barroso

371/2008 El medioambiente y los objetivos de fabricación: un análisis de los modelos estratégicos para su consecución
Lucía Avella Camarero, Esteban Fernández Sánchez y Daniel Vázquez-Bustelo

372/2008 Influence of bank concentration and institutions on capital structure: New international evidence
Víctor M. González and Francisco González

373/2008 Generalización del concepto de equilibrio en juegos de competición política
Mª Dolores López González y Javier Rodrigo Hitos

374/2008 Smooth Transition from Fixed Effects to Mixed Effects Models in Multi-level regression Models
María José Lombardía and Stefan Sperlich

375/2008 A Revenue-Neutral Tax Reform to Increase Demand for Public Transport Services
Carlos Pestana Barros and Juan Prieto-Rodriguez

376/2008 Measurement of intra-distribution dynamics: An application of different approaches to the European regions
Adolfo Maza, María Hierro and José Villaverde

377/2008 Migración interna de extranjeros y ¿nueva fase en la convergencia?
María Hierro y Adolfo Maza

378/2008 Efectos de la Reforma del Sector Eléctrico: Modelización Teórica y Experiencia Internacional
Ciro Eduardo Bazán Navarro

379/2008 A Non-Parametric Independence Test Using Permutation Entropy
Mariano Matilla-García and Manuel Ruiz Marín

380/2008 Testing for the General Fractional Unit Root Hypothesis in the Time Domain
Uwe Hassler, Paulo M.M. Rodrigues and Antonio Rubia

381/2008 Multivariate gram-charlier densities
Esther B. Del Brio, Trino-Manuel Ñíguez and Javier Perote

382/2008 Analyzing Semiparametrically the Trends in the Gender Pay Gap - The Example of Spain
Ignacio Moral-Arce, Stefan Sperlich, Ana I. Fernández-Saínz and Maria J. Roca

383/2008 A Cost-Benefit Analysis of a Two-Sided Card Market
Santiago Carbó Valverde, David B. Humphrey, José Manuel Liñares Zegarra and Francisco Rodriguez Fernandez

384/2008 A Fuzzy Bicriteria Approach for Journal Deselection in a Hospital Library
M. L. López-Avello, M. V. Rodríguez-Uría, B. Pérez-Gladish, A. Bilbao-Terol, M. Arenas-Parra

385/2008 Valoración de las grandes corporaciones farmaceúticas, a través del análisis de sus principales intangibles, con el método de opciones reales
Gracia Rubio Martín y Prosper Lamothe Fernández

386/2008 El marketing interno como impulsor de las habilidades comerciales de las pyme españolas: efectos en los resultados empresariales
Mª Leticia Santos Vijande, Mª José Sanzo Pérez, Nuria García Rodríguez y Juan A. Trespalacios Gutiérrez

387/2008 Understanding Warrants Pricing: A case study of the financial market in Spain
David Abad y Belén Nieto

388/2008 Aglomeración espacial, Potencial de Mercado y Geografía Económica: Una revisión de la literatura
Jesús López-Rodríguez y J. Andrés Faíña

389/2008 An empirical assessment of the impact of switching costs and first mover advantages on firm performance
Jaime Gómez, Juan Pablo Maícas

390/2008 Tender offers in Spain: testing the wave
Ana R. Martínez-Cañete y Inés Pérez-Soba Aguilar

391/2008 La integración del mercado español a finales del siglo XIX: los precios del trigo entre 1891 y 1905
Mariano Matilla García, Pedro Pérez Pascual y Basilio Sanz Carnero

392/2008 Cuando el tamaño importa: estudio sobre la influencia de los sujetos políticos en la balanza de bienes y servicios
Alfonso Echazarra de Gregorio

393/2008 Una visión cooperativa de las medidas ante el posible daño ambiental de la desalación
Borja Montaño Sanz

394/2008 Efectos externos del endeudamiento sobre la calificación crediticia de las Comunidades Autónomas
Andrés Leal Marcos y Julio López Laborda

395/2008 Technical efficiency and productivity changes in Spanish airports: A parametric distance functions approach
Beatriz Tovar & Roberto Rendeiro Martín-Cejas

396/2008 Network analysis of exchange data: Interdependence drives crisis contagion
David Matesanz Gómez & Guillermo J. Ortega

397/2008 Explaining the performance of Spanish privatised firms: a panel data approach
Laura Cabeza Garcia and Silvia Gomez Anson

398/2008 Technological capabilities and the decision to outsource R&D services
Andrea Martínez-Noya and Esteban García-Canal

399/2008 Hybrid Risk Adjustment for Pharmaceutical Benefits
Manuel García-Goñi, Pere Ibern & José María Inoriza

400/2008 The Team Consensus–Performance Relationship and the Moderating Role of Team Diversity
José Henrique Dieguez, Javier González-Benito and Jesús Galende

401/2008 The institutional determinants of CO_2 emissions: A computational modelling approach using Artificial Neural Networks and Genetic Programming
Marcos Álvarez-Díaz , Gonzalo Caballero Miguez and Mario Soliño

402/2008 Alternative Approaches to Include Exogenous Variables in DEA Measures: A Comparison Using Monte Carlo
José Manuel Cordero-Ferrera, Francisco Pedraja-Chaparro and Daniel Santín-González

403/2008 Efecto diferencial del capital humano en el crecimiento económico andaluz entre 1985 y 2004: comparación con el resto de España
Mª del Pópulo Pablo-Romero Gil-Delgado y Mª de la Palma Gómez-Calero Valdés

404/2008 Análisis de fusiones, variaciones conjeturales y la falacia del estimador en diferencias
Juan Luis Jiménez y Jordi Perdiguero

405/2008 Política fiscal en la uem: ¿basta con los estabilizadores automáticos?
Jorge Uxó González y Mª Jesús Arroyo Fernández

406/2008 Papel de la orientación emprendedora y la orientación al mercado en el éxito de las empresas
Óscar González-Benito, Javier González-Benito y Pablo A. Muñoz-Gallego

407/2008 La presión fiscal por impuesto sobre sociedades en la unión europea
Elena Fernández Rodríguez, Antonio Martínez Arias y Santiago Álvarez García

408/2008 The environment as a determinant factor of the purchasing and supply strategy: an empirical analysis
Dr. Javier González-Benito y MS Duilio Reis da Rocha

409/2008 Cooperation for innovation: the impact on innovatory effort
Gloria Sánchez González and Liliana Herrera

410/2008 Spanish post-earnings announcement drift and behavioral finance models
Carlos Forner and Sonia Sanabria

411/2008 Decision taking with external pressure: evidence on football manager dismissals in argentina and their consequences
Ramón Flores, David Forrest and Juan de Dios Tena

412/2008 Comercio agrario latinoamericano, 1963-2000: aplicación de la ecuación gravitacional para flujos desagregados de comercio
Raúl Serrano y Vicente Pinilla

413/2008 Voter heuristics in Spain: a descriptive approach elector decision
José Luís Sáez Lozano and Antonio M. Jaime Castillo

414/2008 Análisis del efecto área de salud de residencia sobre la utilización y acceso a los servicios sanitarios en la Comunidad Autónoma Canaria
Ignacio Abásolo Alessón, Lidia García Pérez, Raquel Aguiar Ibáñez y Asier Amador Robayna

415/2008 Impact on competitive balance from allowing foreign players in a sports league: an analytical model and an empirical test
Ramón Flores, David Forrest & Juan de Dios Tena

416/2008 Organizational innovation and productivity growth: Assessing the impact of outsourcing on firm performance
Alberto López

417/2008 Value Efficiency Analysis of Health Systems
Eduardo González, Ana Cárcaba & Juan Ventura

418/2008 Equidad en la utilización de servicios sanitarios públicos por comunidades autónomas en España: un análisis multinivel
Ignacio Abásolo, Jaime Pinilla, Miguel Negrín, Raquel Aguiar y Lidia García

419/2008 Piedras en el camino hacia Bolonia: efectos de la implantación del EEES sobre los resultados académicos
Carmen Florido, Juan Luis Jiménez e Isabel Santana

420/2008 The welfare effects of the allocation of airlines to different terminals
M. Pilar Socorro and Ofelia Betancor

421/2008 How bank capital buffers vary across countries. The influence of cost of deposits, market power and bank regulation
Ana Rosa Fonseca and Francisco González

422/2008 Analysing health limitations in spain: an empirical approach based on the european community household panel
Marta Pascual and David Cantarero

423/2008 Regional productivity variation and the impact of public capital stock: an analysis with spatial interaction, with reference to Spain
Miguel Gómez-Antonio and Bernard Fingleton

424/2008 Average effect of training programs on the time needed to find a job. The case of the training schools program in the south of Spain (Seville, 1997-1999).
José Manuel Cansino Muñoz-Repiso and Antonio Sánchez Braza

425/2008 Medición de la eficiencia y cambio en la productividad de las empresas distribuidoras de electricidad en Perú después de las reformas
Raúl Pérez-Reyes y Beatriz Tovar

426/2008 Acercando posturas sobre el descuento ambiental: sondeo Delphi a expertos en el ámbito internacional
Carmen Almansa Sáez y José Miguel Martínez Paz

427/2008 Determinants of abnormal liquidity after rating actions in the Corporate Debt Market
Pilar Abad, Antonio Díaz and M. Dolores Robles

428/2008 Export led-growth and balance of payments constrained. New formalization applied to Cuban commercial regimes since 1960
David Matesanz Gómez, Guadalupe Fugarolas Álvarez-Ude and Isis Mañalich Gálvez

429/2008 La deuda implícita y el desequilibrio financiero-actuarial de un sistema de pensiones. El caso del régimen general de la seguridad social en España
José Enrique Devesa Carpio y Mar Devesa Carpio

430/2008 Efectos de la descentralización fiscal sobre el precio de los carburantes en España
Desiderio Romero Jordán, Marta Jorge García-Inés y Santiago Álvarez García

431/2008 Euro, firm size and export behavior
Silviano Esteve-Pérez, Salvador Gil-Pareja, Rafael Llorca-Vivero and José Antonio Martínez-Serrano

432/2008 Does social spending increase support for free trade in advanced democracies?
Ismael Sanz, Ferran Martínez i Coma and Federico Steinberg

433/2008 Potencial de Mercado y Estructura Espacial de Salarios: El Caso de Colombia
Jesús López-Rodríguez y Maria Cecilia Acevedo

434/2008 Persistence in Some Energy Futures Markets
Juncal Cunado, Luis A. Gil-Alana and Fernando Pérez de Gracia

435/2008 La inserción financiera externa de la economía francesa: inversores institucionales y nueva gestión empresarial
Ignacio Álvarez Peralta

436/2008 ¿Flexibilidad o rigidez salarial en España?: un análisis a escala regional
Ignacio Moral Arce y Adolfo Maza Fernández

437/2009 Intangible relationship-specific investments and the performance of r&d outsourcing agreements
Andrea Martínez-Noya, Esteban García-Canal & Mauro F. Guillén

438/2009 Friendly or Controlling Boards?
Pablo de Andrés Alonso & Juan Antonio Rodríguez Sanz

439/2009 La sociedad Trenor y Cía. (1838-1926): un modelo de negocio industrial en la España del siglo XIX
Amparo Ruiz Llopis

440/2009 Continental bias in trade
Salvador Gil-Pareja, Rafael Llorca-Vivero & José Antonio Martínez Serrano

441/2009 Determining operational capital at risk: an empirical application to the retail banking
Enrique José Jiménez-Rodríguez, José Manuel Feria-Domínguez & José Luis Martín-Marín

442/2009 Costes de mitigación y escenarios post-kyoto en España: un análisis de equilibro general para España
Mikel González Ruiz de Eguino

443/2009 Las revistas españolas de economía en las bibliotecas universitarias: ranking, valoración del indicador y del sistema
Valentín Edo Hernández

444/2009 Convergencia económica en España y coordinación de políticas económicas. un estudio basado en la estructura productiva de las CC.AA.
Ana Cristina Mingorance Arnáiz

445/2009 Instrumentos de mercado para reducir emisiones de co2: un análisis de equilibrio general para España
Mikel González Ruiz de Eguino

446/2009 El comercio intra e inter-regional del sector Turismo en España
Carlos Llano y Tamara de la Mata

447/2009 Efectos del incremento del precio del petróleo en la economía española: Análisis de cointegración y de la política monetaria mediante reglas de Taylor
Fernando Hernández Martínez

448/2009 Bologna Process and Expenditure on Higher Education: A Convergence Analysis of the EU-15
T. Agasisti, C. Pérez Esparrells, G. Catalano & S. Morales

449/2009 Global Economy Dynamics? Panel Data Approach to Spillover Effects
Gregory Daco, Fernando Hernández Martínez & Li-Wu Hsu

450/2009 Pricing levered warrants with dilution using observable variables
Isabel Abínzano & Javier F. Navas

451/2009 Information technologies and financial prformance: The effect of technology diffusion among competitors
Lucio Fuentelsaz, Jaime Gómez & Sergio Palomas

452/2009 A Detailed Comparison of Value at Risk in International Stock Exchanges
Pilar Abad & Sonia Benito

453/2009 Understanding offshoring: has Spain been an offshoring location in the nineties?
Belén González-Díaz & Rosario Gandoy

454/2009 Outsourcing decision, product innovation and the spatial dimension: Evidence from the Spanish footwear industry
José Antonio Belso-Martínez

455/2009 Does playing several competitions influence a team's league performance? Evidence from Spanish professional football
Andrés J. Picazo-Tadeo & Francisco González-Gómez

456/2009 Does accessibility affect retail prices and competition? An empirical application
Juan Luis Jiménez and Jordi Perdiguero

457/2009 Cash conversion cycle in smes
Sonia Baños-Caballero, Pedro J. García-Teruel and Pedro Martínez-Solano

458/2009 Un estudio sobre el perfil de hogares endeudados y sobreendeudados: el caso de los hogares vascos
Alazne Mujika Alberdi, Iñaki García Arrizabalaga y Juan José Gibaja Martíns

459/2009 Imposing monotonicity on outputs in parametric distance function estimations: with an application to the spanish educational production
Sergio Perelman and Daniel Santin

460/2009 Key issues when using tax data for concentration analysis: an application to the Spanish wealth tax
José Mª Durán-Cabré and Alejandro Esteller-Moré

461/2009 ¿Se está rompiendo el mercado español? Una aplicación del enfoque de feldstein –horioka
Saúl De Vicente Queijeiro, José Luis Pérez Rivero y María Rosalía Vicente Cuervo

462/2009 Financial condition, cost efficiency and the quality of local public services
Manuel A. Muñiz & José L. Zafra

463/2009 Including non-cognitive outputs in a multidimensional evaluation of education production: an international comparison
Marián García Valiñas & Manuel Antonio Muñiz Pérez

464/2009 A political look into budget deficits.The role of minority governments and oppositions
Albert Falcó-Gimeno & Ignacio Jurado

465/2009 La simulación del cuadro de mando integral. Una herramienta de aprendizaje en la materia de contabilidad de gestión
Elena Urquía Grande, Clara Isabel Muñoz Colomina y Elisa Isabel Cano Montero

466/2009 Análisis histórico de la importancia de la industria de la desalinización en España
Borja Montaño Sanz

467/2009 The dynamics of trade and innovation: a joint approach
Silviano Esteve-Pérez & Diego Rodríguez

468/2009 Measuring international reference-cycles
Sonia de Lucas Santos, Inmaculada Álvarez Ayuso & Mª Jesús Delgado Rodríguez

469/2009 Measuring quality of life in Spanish municipalities
Eduardo González Fidalgo, Ana Cárcaba García, Juan Ventura Victoria & Jesús García García

470/2009 ¿Cómo se valoran las acciones españolas: en el mercado de capitales doméstico o en el europeo?
Begoña Font Belaire y Alfredo Juan Grau Grau

471/2009 Patterns of e-commerce adoption and intensity. evidence for the european union-27
María Rosalía Vicente & Ana Jesús López

472/2009 On measuring the effect of demand uncertainty on costs: an application to port terminals
Ana Rodríguez-Álvarez, Beatriz Tovar & Alan Wall

473/2009 Order of market entry, market and technological evolution and firm competitive performance
Jaime Gomez, Gianvito Lanzolla & Juan Pablo Maicas

474/2009 La Unión Económica y Monetaria Europea en el proceso exportador de Castilla y León (1993-2007): un análisis de datos de panel
Almudena Martínez Campillo y Mª del Pilar Sierra Fernández

475/2009 Do process innovations boost SMEs productivity growth?
Juan A. Mañez, María E. Rochina Barrachina, Amparo Sanchis Llopis & Juan A. Sanchis Llopis

476/2009 Incertidumbre externa y elección del modo de entrada en el marco de la inversión directa en el exterior
Cristina López Duarte y Marta Mª Vidal Suárez

477/2009 Testing for structural breaks in factor loadings: an application to international business cycle
José Luis Cendejas Bueno, Sonia de Lucas Santos, Inmaculada Álvarez Ayuso & Mª Jesús Delgado Rodríguez

478/2009 ¿Esconde la rigidez de precios la existencia de colusión? El caso del mercado de carburantes en las Islas Canarias
Juan Luis Jiménez y Jordi Perdiguero

479/2009 The poni test with structural breaks
Antonio Aznar & María-Isabel Ayuda

480/2009 Accuracy and reliability of Spanish regional accounts (CRE-95)
Verónica Cañal Fernández

481/2009 Estimating regional variations of R&D effects on productivity growth by entropy econometrics
Esteban Fernández-Vázquez y Fernando Rubiera-Morollón

482/2009 Why do local governments privatize the provision of water services? Empirical evidence from Spain
Francisco González-Gómez, Andrés J. Picazo-Tadeo & Jorge Guardiola

483/2009 Assessing the regional digital divide across the European Union-27
María Rosalía Vicente & Ana Jesús López

484/2009 Measuring educational efficiency and its determinants in Spain with parametric distance functions
José Manuel Cordero Ferrera, Eva Crespo Cebada & Daniel Santín González

485/2009 Spatial analysis of public employment services in the Spanish provinces
Patricia Suárez Cano & Matías Mayor Fernández

486/2009 Trade effects of continental and intercontinental preferential trade agreements
Salvador Gil-Pareja, Rafael Llorca-Vivero & José Antonio Martínez-Serrano

487/2009 Testing the accuracy of DEA for measuring efficiency in education under endogeneity
Salvador Gil-Pareja, Rafael Llorca-Vivero & José Antonio Martínez-Serrano

488/2009 Measuring efficiency in primary health care: the effect of exogenous variables on results
José Manuel Cordero Ferrera, Eva Crespo Cebada & Luis R. Murillo Zamorano

489/2009 Capital structure determinants in growth firms accessing venture funding
Marina Balboa, José Martí & Álvaro Tresierra

490/2009 Determinants of debt maturity structure across firm size
Víctor M. González

491/2009 Análisis del efecto de la aplicación de las NIIF en la valoración de las salidas a bolsa
Susana Álvarez Otero y Eduardo Rodríguez Enríquez

492/2009 An analysis of urban size and territorial location effects on employment probabilities: the spanish case
Ana Viñuela-Jiménez, Fernando Rubiera-Morollón & Begoña Cueto

493/2010 Determinantes de la estructura de los consejos de administración en España
Isabel Acero Fraile y Nuria Alcalde Fradejas

494/2010 Performance and completeness in repeated inter-firm relationships: the case of franchising
Vanesa Solis-Rodriguez & Manuel Gonzalez-Diaz

495/2010 A Revenue-Based Frontier Measure of Banking Competition
Santiago Carbó, David Humphrey & Francisco Rodríguez

496/2010 Categorical segregation in social networks
Antoni Rubí-Barceló

497/2010 Beneficios ambientales no comerciales de la directiva marco del agua en condiciones de escasez: análisis económico para el Guadalquivir
Julia Martin-Ortega, Giacomo Giannoccaro y Julio Berbel Vecino

498/2010 Monetary integration and risk diversification in eu-15 sovereign debt markets
Juncal Cuñado & Marta Gómez-Puig

499/2010 The Marshall Plan and the Spanish autarky: A welfare loss analysis
José Antonio Carrasco Gallego

500/2010 The role of learning in firm R&D persistence
Juan A. Mañez, María E. Rochina-Barrachina, Amparo Sanchis-Llopis & Juan A. Sanchis-Llopis

501/2010 Is venture capital more than just money?
Marina Balboa, José Martí & Nina Zieling

502/2010 On the effects of supply strategy on business performance: do the relationships among generic competitive objectives matter?
Javier González-Benito

503/2010 Corporate cash holding and firm value
Cristina Martínez-Sola, Pedro J. García-Teruel & Pedro Martínez-Solano

504/2010 El impuesto de flujos de caja de sociedades: una propuesta de base imponible y su aproximación contable en España
Lourdes Jerez Barroso y Joaquín Texeira Quirós

505/2010 The effect of technological, commercial and human resources on the use of new technology
Jaime Gómez & Pilar Vargas

506/2010 ¿Cómo ha afectado la fiscalidad a la rentabilidad de la inversión en vivienda en España? Un análisis para el periodo 1996 y 2007
Jorge Onrubia Fernández y María del Carmen Rodado Ruiz

507/2010 Modelización de flujos en el análisis input-output a partir de la teoría de redes
Ana Salomé García Muñiz

508/2010 Export-led-growth hypothesis revisited. a balance of payments approach for Argentina, Brazil, Chile and Mexico
David Matesanz Gómez & Guadalupe Fugarolas Álvarez-Ude

509/2010 Realised hedge ratio properties, performance and implications for risk management: evidence from the spanish ibex 35 spot and futures markets
David G McMillan & Raquel Quiroga García

510/2010 Do we sack the manager... or is it better not to? Evidence from Spanish professional football
Francisco González-Gómez, Andrés J. Picazo-Tadeo & Miguel Á. García-Rubio

511/2010 Have Spanish port sector reforms during the last two decades been successful? A cost frontier approach
Ana Rodríguez-Álvarez & Beatriz Tovar

512/2010 Size & Regional Distribution of Financial Behavior Patterns in Spain
Juan Antonio Maroto Acín, Pablo García Estévez & Salvador Roji Ferrari

513/2010 The impact of public reforms on the productivity of the Spanish ports: a parametric distance function approach
Ramón Núñez-Sánchez & Pablo Coto-Millán

514/2010 Trade policy versus institutional trade barriers: an application using "good old" ols
Laura Márquez-Ramos, Inmaculada Martínez-Zarzoso & Celestino Suárez-Burguet

515/2010 The "Double Market" approach in venture capital and private equity activity: the case of Europe
Marina Balboa & José Martí

516/2010 International accounting differences and earnings smoothing in the banking industry
Marina Balboa, Germán López-Espinosa & Antonio Rubia

517/2010 Convergence in car prices among European countries
Simón Sosvilla-Rivero & Salvador Gil-Pareja

518/2010 Effects of process and product-oriented innovations on employee downsizing
José David Vicente-Lorente & José Ángel Zúñiga-Vicente

519/2010 Inequality, the politics of redistribution and the tax-mix
Jenny De Freitas

520/2010 Efectos del desajuste educativo sobre el rendimiento privado de la educación: un análisis para el caso español (1995-2006)
Inés P. Murillo, Marta Rahona y Mª del Mar Salinas

521/2010 Sructural breaks and real convergence in opec countries
Juncal Cuñado

522/2010 Human Capital, Geographical location and Policy Implications: The case of Romania
Jesús López-Rodríguez, Andres Faiña y Bolea Cosmin-Gabriel

523/2010 Organizational unlearning context fostering learning for customer capital through time: lessons from SMEs in the telecommunications industry
Anthony K. P. Wensley, Antonio Leal-Millán, Gabriel Cepeda-Carrión & Juan Gabriel Cegarra-Navarro

524/2010 The governance threshold in international trade flows
Marta Felis-Rota

525/2010 The intensive and extensive margins of trade decomposing exports growth differences across Spanish regions
Asier Minondo Uribe-Etxeberria & Francisco Requena Silvente

526/2010 Why do firms locate r&d outsourcing agreeements offshore? the role of ownership, location, and externalization advantages
Andrea Martínez-Noya, Esteban Gárcía-Canal & Mauro f. Guillén

527/2010 Corporate Taxation and the Productivity and Investment Performance of Heterogeneous Firms: Evidence from OECD Firm-Level Data
Norman Gemmell, Richard Kneller, Ismael Sanz & José Félix Sanz-Sanz

528/2010 Modelling Personal Income Taxation in Spain: Revenue Elasticities and Regional Comparisons
John Creedy & José Félix Sanz-Sanz

529/2010 Mind the Remoteness!. Income disparities across Japanese Prefectures
Jesús López-Rodríguez, Daisuke Nakamura

530/2010 El nuevo sistema de financiación autonómica: descripción, estimación empírica y evaluación
Antoni Zabalza y Julio López Laborda

531/2010 Markups, bargaining power and offshoring: an empirical assessment
Lourdes Moreno & Diego Rodríguez

532/2010 The snp-dcc model: a new methodology for risk management and forecasting
Esther B. Del Brio, Trino-Manuel Ñíguez & Javier Perote