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Multivariate Analysis of a Time Series EU ETS: Methods and Applications in Carbon Finance

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Abstract

Climate Change (CC) is a major issue of our century. Controlling the constraints of Greenhouse Gas (GHG) emissions through transformation into opportunities (Wettestad and Skjaerseth, 2007), in an organization to increase industrial production, has become a necessity. The main reason for this adoption was the effectiveness of energy management and responsible linkages that are being developed to determine the issues and opportunities of carbon finance for organizations. This article is part of the 21st Conference of the Parties 2015 (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) in France in Paris. In this regard, it is the ultimate opportunity to present an accurate diagnosis of GHG emissions quantification and a holistic review of Climate Change (CC) recommendations. This scientific contribution was, in fact, a natural extension of the 22nd Conference of the Parties (COP22) hosted by the Kingdom of Morocco in Marrakech in 2016. Indeed, COP21 and COP22 Are two crucial deadlines, since they must lead to a new international agreement on climate, applicable to all countries, with the objective of keeping global warming below 2 ° C. This article aims to analyze and study the performance of Carbon Finance in the EU Sustainable Finance Business Emissions Trading Scheme (EU ETS). We will develop our quantitative methodology for the econometric study of the EU Emissions Trading Scheme (EU ETS) for both phases [Phase I: 2005-2007 and Phase II: 2008-2012] (Alberola, Chevallier and Cheze, 2009). The increasing complexity of Climate Change (CC) challenges creates a systemic view of EU ETS companies and a macroeconomic framework for environmental issues. In this context, we will develop our quantitative methodology adopted for the econometric study of the EU Emissions Trading Scheme (EU ETS) for the two phases of the EU ETS [Phase I: 2005-2007 and Phase II: 2008 -2012]. In the same direction, this scientific research addresses the thrilling question: "What are the responsible issues and sustainable and sustainable opportunities for the adoption of carbon finance for EU ETS companies for the development of a"2 °C?", In order to facilitate climate decision-making and to limit CO2 emissions. The real challenge is to contain the increasing complexity of Climate Change (CC) in a way that is compatible with the warming scenario limited to + 2 ° C. The development of the EU ETS is the reticular example of this turning point.

Key words: Sustainable Development; Kyoto Protocol; Carbon Finance; Multivariate Analysis; EU ETS.

JEL Classification: G30, O16, Q01, Q51, Q54.

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Introduction

The scientific community began to take an interest in Climate Change (CC) in the 1970s. There is now a broad consensus on the responsibility for human-induced greenhouse gas (GHG) emissions in since the end of the pre-industrial era. The international community has since agreed on the need to act quickly to reduce them in order to limit the scale of future climate change. According to the IPCC, global average temperature could rise from 1.1 ° C to 6.4 ° C by the end of the century. Given the disruptions, the consensus of states reached

in Copenhagen and Durban aims to limit the increase in the average temperature of the planet to two degrees compared to the pre-industrial levels. To stay under this limit, scientific experts believe that at least half of global greenhouse gas emissions must be halved by 2050 (Bunn and Fezzi, 2007). Global warming is increasingly seen by investors as a long-term risk factor that could have a negative impact on asset valuation (Alberola and Chevallier, 2009).

In this context, a set of approaches and methodologies have been defined in recent years to evaluate the contributions of different sources of greenhouse gas (GHG) emissions, to quantify CO2 emissions and to Progress reports for a Sustainable Development. This transitional path involves a reorientation of part of the amounts invested in the carbon intensive sectors to the low-carbon sectors (Broome, 1992).

To respond to the challenges of climate change, a major reorientation of these approaches and methodologies is primordial. These strategies generate a reallocation of CO2 emissions, enabling industrial companies to first make an objective assessment of their emissions and to shed light on the resulting priorities (given the carbon limits recommended). The EU ETS to better understand the risks associated with Climate Change (CC) and to identify financial development opportunities related to GHG emissions (Alberola, Chevallier, Cheze, 2008), thus presenting existing CO2 pricing practices (EUA) By means of the econometric analysis of the two phases of the EU ETS Our article is organized as follows:

- **Axis 1**: Treatments of the determinants of CO2 prices (EUA);
- **Axis 2:** Specification of the variables / concepts of the EU ETS econometric model;
- **Axis 3**: Restitution, validation and interpretation of EU ETS results.

I. The determinants of CO2 prices (UAE): fundamental analysis

The CO2 prices within the framework of the EU ETS depend on several determinants (variable)[1]. « Since 1 January 2005, every tonne of carbon emitted into the atmosphere in Europe by about 10,600 energy intensive installations has a price. The EU ETS covers 46% of the CO2 emissions from industries in Europe and aims to help Member States achieve compliance with their commitments under the Kyoto Protocol during 2008-2012. While the international quota trading system allows for exchange between governments from 2008, the EU ETS extends the exchange of quotas at the level of the firm […] ».[2]

Following this principle, it can be asserted that the real objective of the EU ETS to offer incentives to industrial firms to reduce their CO2 emissions and thus encourage the adoption of low-carbon technologies, to develop Efficiency Energy (EE), Renewable Energies (Renewable Energies) and the low carbon economy (Capoor and Ambrosi, 2009). We give an overview of the regulations governing Carbon Finance (Bokenkamp, La Flash, Bachrach Wang, 2005).

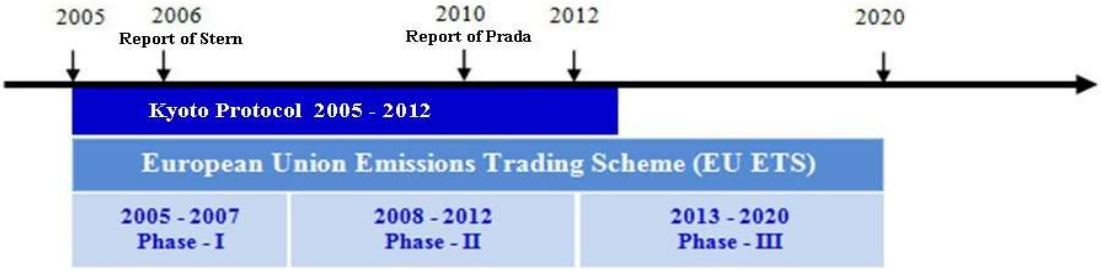

Figure 1. Overview of regulations governing carbon finance

Source: by authors.

The figure above highlights the three main phases of carbon finance. In 2006 (in Phase I), the Stern's report [3] has established a prize concerned «The Environmental Threat of Climate Change (CC) » [4].

[1] The EU Emissions Trading System (EU ETS) is a market created by European Directive 2003/87 / EC.

[2] Translated. Chevallier, Julien. (2008). Les règles de fonctionnement du marché européen du carbone (2005-2007): le rôle du stockage et de l'emprunt de quotas, les fondamentaux du prix et les stratégies de gestion des risques ; 112.

[3] Nicholas STERN, former chief economist at the World Bank. The "Stern Report", given to Tony BLAIR in October 2006, highlighted Climate Change in the economic sphere setting a price on the environmental threat.

[4] Morocco, organizer of COP 22 (Conference of the Parties "COP" to the United Nations Framework Convention on Climate Change "UNFCCC") after COP 21 in Paris this year 2015, hoped to be decisive in the major global negotiations on Climate Change (CC). Source: http://www.usinenouvelle.com/article/le-commissaire-europeen-a-l-energie-en-visite-au-maroc-pour-parler-integration-regionale.N328289

With this in mind, in 2010 (Phase II), the Prada's report created twenty-eight (28) technical recommendations for the correct regulation of carbon markets (Chevallier, 2012). « Most of them are already being pursued, either at Community level, in particular with the launch of Phase III of the European market […] Their aim is to ensure the efficient functioning of these markets, and not to restrict its scope. Taken as a whole, they stress that the functioning of any market economy requires an appropriate institutional framework, hence the importance of this work» (Translated. Bureau, 2010).

Our study focuses on price changes in the EUA[1], being the most liquid carbon asset. In this regard, we highlighted the daily spot price of the EUA to highlight the daily changes affecting this price, given the high volatility in this market (Bourgeois, 2010). Following this principle, we studied the determinants of CO2 prices (EUA), as follows:

- The first determinant: the price of carbon: **price changes in the EUA**;
- The second determinant: **primary energy prices: oil, natural gas and coal**;
- The third determinant: **Clean Dark Spread, Clean Spark Spread and Switch Price**;
- The fourth determinant: **atmospheric variables**;
- The fifth and determinant: **SBF250 variations and the Subprime crisis**.

In the next section, we will present our research hypotheses, the endogenous variable, the exogenous variables and the specification of the econometric model of the EU ETS.

II. Specification of econometric model variables / concepts

II.1 Specification of modeling variables

We will highlight at this level the explained variable and the explanatory variables in our econometric work in order to test our first research hypothesis as follows:

General research hypothesis: The performance of the Carbon Finance Strategy for Sustainable Finance is based on the reaction of the fundamentals of quota prices of the European Union Emissions Trading Scheme (EU ETS).

In this regard, this general hypothesis of research suggests two adjacent under-hypotheses of research as follows:

- **Adjacent research hypothesis n°1-1**: The performance of the Carbon Finance Strategy for Sustainable Finance is influenced by the integration of information on CO2 emissions during Phase I of the EU ETS.
- **Adjacent research hypothesis n°1-2**: The performance of the Carbon Finance Strategy for Sustainable Finance is influenced by the Subprime crisis during the EU ETS Phase II.

II.1.1 Specification of the variable to be explained (endogenous variable)

This explained variable is measured by the change of spot EUA prices (Criqui and Kouvaritakis, 2000). The European Union Emissions Trading Scheme (EU ETS) can be used to express the yield from the carbon market allocation point of view (Delarue and D'haeseleet, 2007).

II.1.2 Specification of explanatory variables (exogenous variables)

At this level of analysis, our objective is to highlight the link between the performance of the strategies of the industrial players subject to the European Union Emissions Trading Scheme (EU ETS) for both periods via the variation of the spot price EUA and the Primary energy variables, atmospheric variables, CO2 emission information variables, fuel modification variables, structural movement variables and the subprime crisis variable).

- **The variables of the first period 2005 – 2007**

The explanatory variables for the first test phase of the European Union Emissions Trading Scheme (EU ETS) are presented in four groups of explanatory variables. The **group [A]** contains the variables of primary energies namely **Var.01**: Variation of Brent price, **Var.02**: Variation of Gas price and **Var.03**: Variation of the price of Coal. Then, **group [B]** contains the two variables for fuel modification of energy production as

[1] European Union Allowance.

follows: **Var.04**: Clean Spark Spread and **Var.05**: Clean Dark Spread. As for **group [C]**, we have the two structural movement variables, **Var.06**: Dummy Structural Movement and **Var.08**: The impact of economic activity and the financial crisis on electricity production - Variations SBF250. Finally, the **group [D]** is dedicated to the three atmospheric variables, **Var.09**: Extremely Cold Dummy, **Var.10**: Extremely Hot Dummy and **Var.11**: Seasonal Normal Variations. According to our econometric analyzes of the first period of the EU ETS, we have chosen **ten (10) variables**. In this respect, we can assume that **six (06) explanatory variables** have a **positive predicted sign** and **four (04) explanatory variables** have a **negative predicted sign**.

▪ **The variables of the second period 2008 - 2010**

The explanatory variables for the second period, known as the commitment phase, of the Kyoto Protocol (PK) of the European Union Emissions Trading Scheme (EU ETS) are also presented in four (4) groups of explanatory variables (Edmonds, Mac Cracken, Sands and Kim, 1998). The **group [A]** contains the variables of primary energies namely **Var.01**: Variation of Brent price, **Var.02**: Variation of Gas price and **Var.03**: Variation of the price of Coal. Then, **group [B]** contains the two fuel modification variables of energy production as follows: **Var.04**: Clean Spark Spread and **Var.05**: Clean Dark Spread. Concerning **group [C]**, we are able to show the two variables of the structural movement, **Var.07**: Dummy Structural Movement and **Var.08**: The impact of economic activity and the financial crisis on electricity production - Variations SBF250. Lastly, the **group [D]** contains to three (3) atmospheric variables, **Var.09**: Extremely Cold Dummy, **Var.10**: Extremely Hot Dummy and **Var.11**: Seasonal Normal Variations. To summarize, we selected for the second period of the EU ETS, **ten (10) variables** as the first period of the EU ETS. Nevertheless, we replaced the **variable Dummy Structural Movement** by the **variable Dummy Crisis of Subprimes**. For this purpose, we can conclude that six **(06) explanatory variables** have a **positive predicted sign** and **four (04) explanatory variables** have a **negative predicted sign**.

II.2 Specification of the EU ETS Econometric Model

Economically speaking, our study aims to show the performance of the strategies of the actors of the EU ETS via the EUA price. In order to achieve this, we can retain a **multiple linear model (multiple regression)** as the theory formalizes it, with the introduction of two (2) categories of variables: the **endogenous variable** and the several **exogenous variables**. « The general linear model is a generalization of the simple regression model in which several explanatory variables ».[1]

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + ... + \beta_k X_{kt} + \varepsilon_t \text{ pour } t = 1,....,n \qquad \text{(II.2.1)}^2 \qquad (1)$$

« The parameter β_i is called partial regression coefficient, it measures the variation of Y when X_i increases by one unit and the other explanatory variables are kept constant. ε represents the random error, it is unobservable and includes both measurement errors on the observed values of Y and all other explanatory factors not taken into account in the model» (Translated. Elmarhoum, 2013, p. 13).

The multiple regression aims at explaining a dependent variable Y and p explanatory variables X_1, X_2, X_3 ,…, X_p (p>1). Then, if this relationship is confirmed, evaluate its intensity. To determine the variables that influence the performance of EU ETS stakeholders' strategies via the EUA price, we adopted the formulation and model that we want to estimate, as follows:

$$\text{PERF } EUA_{i,t} = \alpha W_{i,t} + \beta X_{i,t} + \chi Z_{i,t} + \delta Y_{i,t} + \varepsilon_{i,t} \text{ (II.2.2)}^3 \qquad (2)$$

To be clear, our model includes four (4) groups of addressable variables for action on the EU ETS Stakeholder Strategy Performance via the EUA price ($\text{PERF } EUA_{i,t}$) and a random variable (error term), as follows:

$W_{i,t}$: Variables of primary energies (Group A)

$X_{i,t}$ Fuel Modification Variables for Energy Production (Group B)

$Z_{i,t}$ Variables of structural movement (Group C)

[1]Adapted and translated. BOURBONNAIS, Régis. Econométrie : manuel et exercices corrigés, 47.

[2]Loc. cit.s

[3] t = 1,…, 94 with i = Phase I with t = 1,…, 122 avec i = Phase II.

$Y_{i,t}$ Atmospheric variables (Group D)

$\varepsilon_{i,t}$ Random variable (error term), following a normal distribution $N = (0, \delta^2)$

III. Results of the econometric analysis of the EU ETS

We present here the analysis and validation of the results of our econometric model for phase I and phase II of the European Union Emissions Trading Scheme.

III.1 Analysis and validation of the results of the econometric model of Phase I EU ETS.

Our objective for Phase I of the European Union Emissions Trading Scheme (EU ETS) is to test the adjacent hypothesis, namely:

▪ **Adjacent research hypothesis n°1-1**: The performance of the Carbon Finance Strategy for Sustainable Finance is influenced by the integration of information on CO2 emissions during Phase I of the EU ETS.

Analysis of the data in this phase I [1] of the European Union Emissions Trading Scheme (EU ETS) allowed us to compare our econometric results and the state of play that we conducted above (Ellerman and Montero, 2007). According to the econometric results [2], the analysis of the coefficients « **R^2 ou R-squared** » and « **R^2 adjusted** » or « **Adjusted R-squared** » are different from the results of the multiple regression of phase I of the EU ETS. Indeed, we have **R^2** or **R-squared = 0.355356**, Therefore the variations of the independent variables account for 35.53% of the price performance of the EUA. The objective is to show the correlations between the price variations of the EUA and the variations of the other variables.

To conclude this point in **Phase I of the EU ETS**, we identified four (4) types of determinants explaining the EUA price:

1. the first determinant **"Changes in the price of gas (Gas)" [Var. 02]** (EUA market regulatory information);

2. the second determinant "**Changes in the price of coal (Coal)" [Var. 03]**;

3. the third determinant **"Clean Dark Spread (CDS)" [Var. 05]**;

4. and in the end **"Seasonal Normal Variations (VNS)" [Var. 11]**.

In this respect, we have attempted to show econometrically using multiple regression that changes in the price of carbon (EUA) react to changes in primary energy prices (mainly natural gas) during the 2005-2007 test period. At the **5%** level of significance, we can say that there is a **significant relationship** between the performance of the Carbon Finance strategy for sustainable finance. This relationship is influenced by the integration of information on CO2 emissions during Phase I. Ultimately, this analysis indicates that our **adjacent research hypothesis** n°1-1 is thus **verified**.[3]

III.2 Analysis and validation of the results of the econometric model of Phase II EU ETS.

The objective for Phase II [4] of the European Union Emissions Trading Scheme (EU ETS) is to test the second adjacent hypothesis, namely:

▪ **Adjacent research hypothesis n°1-2**: The performance of the Carbon Finance Strategy for Sustainable Finance is affected by the subprime crisis during Phase II of the EU ETS. The analysis of this phase of the European Union Emissions Trading Scheme (EU ETS) has allowed us to compare our econometric results and the inventory we conducted previously. Referring to our econometric results[5], the analysis of the coefficients « **R^2 or R-squared** » et « **R^2 adjusted** » or « **Adjusted R-squared** » are different from the results of the multiple regression of phase II of the EU ETS. Indeed, we have **R^2** ou **R-squared = 0.846111**, therefore the variations of the independent variables explain **84,61%** Of the price performance of the UAE. The objective is to show the correlations between the price variations of the EUA and the variations of the other variables.

To conclude this point in **phase II of the EU ETS**, we identified five (5) types of determinants explaining the

[1] Bourgeois (2010) is the source of data for period I of the EU ETS.
[2] Econometric results provided by the Eviews software version 7.2.
[3] Fisher's statistic (F-test) allows us to validate our model. By consulting F tabulated (theoretical or critical) with the degrees of freedom of 5% and the number of observations; we find the tabulated F (theoretical or critical) which is equal to 2,04.
[4] Bourgeois (2010) is the source of data for period I of the EU ETS.
[5] Econometric results provided by the Eviews software version 7.2.

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EUA price:

1. The First Determinant **"Variations In The Price Of Brent (Brent)" [Var. 01]**;

2. The Second Determinant **"Changes in the price of coal (Coal)" [Var. 03]**;

3. the third determinant the **variable "The impact of economic activity and the financial crisis on the production of electricity (SBF)" [Var. 08] ;**

4. The fourth determinant is **"Extremely Hot Dummy (DEC)" [Var. 10]**;

5. Finally, the last determinant **"Seasonal Normal Variations (VNS)" [Var. 11]**.

In this regard, we have attempted to show econometrically using multiple regression that carbon price changes (EUA) respond to the impact of the subprime crisis during period II: 2008-2010. At the **5%** significance level we can say that there is a **significant relationship** between the performance of the Carbon Finance Strategy for Sustainable Finance is influenced by the Subprime crisis during Phase II. Ultimately, this analysis indicates that our **adjacent research hypothesis n°1-2** is thus verified.[1]

Conclusion and future recommendations: The development of «Finance limiting global warming to 2°C » difficult but essential

Carbon Finance will have consequences for the various economic actors, directly for industrial activities and indirectly for the rest of the socio-economic system. According to the literature, market mechanisms have led to the emergence of a carbon price signal, which companies must incorporate into their strategies in order to optimize their reductions in GHG emissions (Nordhaus, 1991). The interest for the company is to understand the ins and outs of Carbon Finance and to make the best use of allocated quotas in order to optimize their economic, financial and environmental performance. Thus, our central question of our research was formulated in the following way:

« **What are the responsible issues and sustainable opportunities for the adoption of carbon finance for EU ETS companies for the development of a "2 ° C Finance"?** ».

In practice, several determinants of CO2 prices (EUA) exist to promote the resilience of Carbon Finance, which can be characterized by the price of carbon, primary energy prices: oil, natural gas and coal, Clean Dark Spread, The Clean Spark Spread and the Switch Price, the atmospheric variables and the SBF250 and the Subprime crisis. Unlike solutions that are inflexible or irreversible, that increase Climate Change or reduce the incentive to adapt to Carbon Finance would be poorly adopted (Springer, 2003).

The mechanisms of Carbon Finance have a prominent place for the realization of the Sustainable Development (SD) agendas for Carbon Finance to become « Finance 2 ° C». In these circumstances, not including the anticipation of Climate Change (CC) and the adoption of Carbon Finance (especially the CO2 exchange system) will increase the risk of making our existence vulnerable to uncertainties while eliminating the actions and carbon transactions available to Sustainable Finance and Sustainable Development (SD). It seems very useful to inject less GHGs in absolute terms, but the real challenge is to reduce the GHGs to a threshold that limits the rise in temperature to 2°C (Toth, 1999). To carry out our study, we decided to treat each period of the EU ETS in a different way according to their specificities and the academic work already carried out. In addition to the results of the econometric tool itself and their analysis, the process of sensitizing the industrial players and refocusing reflection on their own interest, that maximizing profitability (or avoid reducing profitability) a project to exchange EU ETS CO2 allowances for current and future climate change.

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[1] Fisher's statistic (F-test) allows us to validate our model. By consulting F tabulated (theoretical or critical) with the degrees of freedom of 5% and the number of observation ; we find the tabulated F (theoretical or critical) which is equal to 2,01.

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Appendix

Table 1. The four groups of variables in the econometric study of the EU ETS

$PERF\ EUA_{i,t}$	Performance of the strategies of EU ETS actors via the EUA price	Groups of variables
$W_{i,t}$	primary energies variables	Group A
$Brent_{i,t}$	Variation of Brent price	(Var. 01)
$Gas_{i,t}$	Variation of Gas price	(Var. 02)
$Coal_{i,t}$	Variation of Coal price	(Var. 03)
$X_{i,t}$	Fuel modification variables of energy production	Group B
$CSS_{i,t}$	Clean Spark Spread	(Var. 04)
$CDS_{i,t}$	Clean Dark Spread	(Var. 05)
$Z_{i,t}$	Structural movement variables	Group C
$DMS_{i,t}$	Dummy Structural Movement for Phase I	(Var. 06)
$DCS_{i,t}$	Dummy Subprime Crisis for Phase II	(Var. 07)
$SBF_{i,t}$	The impact of economic activity and the financial crisis on electricity production - Variations SBF 250	(Var. 08)
$Y_{i,t}$	Atmospheric variables	Group D
$DEF_{i,t}$	Extremely Cold Dummy	(Var. 09)
$DEC_{i,t}$	Extremely Hot Dummy	(Var. 10)
$VNS_{i,t}$	Seasonal Normal Variations	(Var. 11)
$\varepsilon_{i,t}$	Random variable (error term), following a normal distribution $N=(0,\delta^2)$	Term of error

Table 2. Results of the stationarity tests of the variables of the model of phase I EU ETS

	Without constant term or trend	With constant term	With trend	With constant term and trend	First Difference	Conclusion
Brent	S	S	S	NS	NS	RVL
CDS	S	S	NS	NS	NS	RVL
Coal	S	S	S	S	NS	RVL
CSS	S	S	S	S	NS	RVL
DEC	S	S	S	S	S	RVL
DEF	S	S	NS	NS	NS	RVL
GAS	S	S	S	NS	NS	RVL
SBF	S	S	S	S	NS	RVL
VNS	S	S	S	NS	NS	RVL

N.B: S = Stationary; NS = No- Stationary; RVL = Retain the Variable in Level

Table 3. Results of the stationarity tests of the variables of the model of phase II EU ETS

	Without constant term or trend	With constant term	With trend	With constant term and trend	First Difference	Conclusion
Brent	S	S	S	NS	NS	RVL
CDS	S	S	NS	NS	S	RVL
Coal	S	S	S	S	S	RVL
CSS	S	S	S	S	S	RVL
DEC	S	S	S	S	NS	RVL
DEF	S	S	S	NS	S	RVL
GAS	S	S	S	S	NS	RVL
SBF	S	S	S	S	NS	RVL
VNS	S	S	S	S	S	RVL

N.B : S = Stationary ; NS = No- Stationary ; RVL = Retain the Variable in Level

Table 4. Results of the multiple regression of the phase I of the EU ETS under Eviews

Dependent Variable: PERF_EUA				
Method: Least Squares				
Date: 03/29/15 Time: 15:20				
Sample: 1 94				
Included observations: 94 period I EU ETS				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
	-0.014148	0.007521	-1.881095	0.0634
BRENT	-0.222378	0.214916	-1.034717	0.3038
CDS	-0.296163	0.050686	-5.843100	0.0000
COAL	-0.716404	0.233243	-3.071490	0.0029
CSS	0.014616	0.012034	1.214549	0.2279
DEC	-0.081566	0.052840	-1.543649	0.1264

Table 4 (cont.). Results of the multiple regression of the phase I of the EU ETS under Eviews

DEF	-0.016117	0.029989	-0.537439	0.5924
GAS	0.169822	0.062405	2.721279	0.0079
SBF	-0.737676	0.372122	-1.982347	0.0507
VNS	-0.000931	0.000336	-2.770596	0.0069
R-squared	0.417741	Mean dependent var		-0.008830
Adjusted R-squared	0.355356	S.D. dependent var		0.062128
S.E. of regression (SER)	0.049883	Akaike info criterion		-3.058005
Sum squared resid	0.209014	Schwarz criterion		-2.787441
Log likelihood	153.7262	Hannan-Quinn criter.		-2.948717
F-statistic	6.696190	Durbin-Watson stat		2.138006
Prob(F-statistic)	0.000000			

Table 5. Results of the multiple regression of the phase I of the EU ETS under Eviews

Dependent Variable: PERF_EUA				
Method: Least Squares				
Date: 02/11/16 Time: 21:55				
Sample: 1/04/2008 4/30/2010				
Included observations: 122				
Convergence achieved after 45 iterations				
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed				
bandwidth = 5.0000)				
MA Backcast: OFF (Roots of MA process too large) period II EU ETS				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
BRENT	0.491407	0.051782	9.489870	0.0000
CDS	0.022791	0.012475	1.826995	0.0704
COAL	-0.489649	0.058956	-8.305298	0.0000
CSS	-0.001433	0.000634	-2.259724	0.0258
DCS	0.446075	0.637015	0.700258	0.4852
DEC	0.000714	0.003979	0.179349	0.8580
DEF	-0.085395	0.004735	-18.03666	0.0000
GAS	0.151893	0.054127	2.806210	0.0059
SBF	0.405895	0.079291	5.119035	0.0000
VNS	-0.005114	0.001142	-4.479786	0.0000
C	0.007138	0.002342	3.047188	0.0029
MA(1)	1.092250	0.185425	5.890528	0.0000
R-squared	0.860101	Mean dependent var		0.007049
Adjusted R-squared	0.846111	S.D. dependent var		0.034966
S.E. of regression (SER)	0.013717	Akaike info criterion		-5.647222
Sum squared resid	0.020696	Schwarz criterion		-5.371417
Log likelihood	356.4806	Hannan-Quinn criter.		-5.535199
F-statistic	61.48021	Durbin-Watson stat		1.794808
Prob(F-statistic)	0.000000			
Inverted MA Roots	-1.09			
	Estimated MA process is noninvertible			

Table 6. Chronological series of phase I EU ETS: Brent, Gas, Coal, CSS, CDS

28	08/07/2005	0.01	0.00	0.00	0.02	0.00	0.00
29	15/07/2005	-0.05	-0.01	0.02	0.00	0.03	0.06
30	22/07/2005	-0.21	0.02	0.01	0.00	-0.18	0.05
31	29/07/2005	0.11	0.03	0.00	-0.04	-0.40	-0.25
32	05/08/2005	-0.06	0.01	0.02	-0.05	0.28	0.22
33	12/08/2005	0.04	0.06	-0.01	0.00	0.10	0.01
34	19/08/2005	0.00	-0.03	0.00	0.04	-0.08	-0.10
35	26/08/2005	0.02	0.00	-0.01	-0.02	-0.11	-0.17
36	02/09/2005	0.05	0.01	0.28	-0.04	-0.24	0.08
37	09/09/2005	-0.04	-0.03	-0.02	0.01	-0.31	0.10
38	16/09/2005	-0.03	-0.02	0.00	0.01	0.30	0.16
39	23/09/2005	0.02	-0.04	-0.08	-0.03	0.04	-0.04
40	30/09/2005	0.05	-0.01	0.00	-0.04	0.46	0.09
41	07/10/2005	0.01	-0.07	-0.07	-0.02	-0.79	0.09
42	14/10/2005	0.01	0.00	0.01	0.01	1.12	0.07
43	21/10/2005	-0.06	-0.03	0.02	0.01	-0.15	-0.03
44	28/10/2005	0.02	0.02	-0.02	-0.02	-0.13	0.04
45	04/11/2005	-0.03	0.02	0.29	-0.02	-3.05	-0.07
46	11/11/2005	0.06	-0.06	0.26	0.01	1.43	0.05
47	18/11/2005	-0.06	-0.03	-0.10	-0.01	0.12	0.24

Table 6 (cont.). Chronological series of phase I EU ETS: Brent, Gas, Coal, CSS, CDS

48	25/11/2005	-0.08	-0.01	0.06	0.02	0.81	0.24
49	02/12/2005	0.04	0.04	0.17	0.02	0.10	0.11
50	09/12/2005	-0.04	-0.01	-0.19	0.01	-0.11	0.01
51	16/12/2005	0.00	-0.03	-0.02	-0.05	-0.33	0.19
52	23/12/2005	-0.03	0.02	-0.05	0.02	-0.75	0.22

Source: Données Thomson Reuters (Bourgeois. 2010).

Table 7. Chronological series of phase I EU ETS: DMS. SBF. DEF. DEC. VNS

28	08/07/2005	0.01	0.00	0.00	0.00	0.00	1.46
29	15/07/2005	-0.05	0.00	0.01	0.00	0.00	1.11
30	22/07/2005	-0.21	0.00	0.02	0.00	0.00	-2.63
31	29/07/2005	0.11	0.00	0.01	0.00	0.00	-4.02
32	05/08/2005	-0.06	0.00	0.01	0.00	0.00	-4.42
33	12/08/2005	0.04	0.00	-0.01	0.00	0.00	-3.64
34	19/08/2005	0.00	0.00	0.01	0.00	0.00	-3.06
35	26/08/2005	0.02	0.00	0.00	0.00	0.00	-1.87
36	02/09/2005	0.05	0.00	-0.03	0.00	0.00	-5.02
37	09/09/2005	-0.04	0.00	0.02	0.00	0.00	-8.47
38	16/09/2005	-0.03	0.00	0.02	0.00	0.00	-9.11
39	23/09/2005	0.02	0.00	0.01	0.00	0.00	-8.28
40	30/09/2005	0.05	0.00	-0.01	0.00	0.00	-6.64
41	07/10/2005	0.01	0.00	0.03	0.00	0.00	-15.79
42	14/10/2005	0.01	0.00	-0.02	0.00	0.00	-14.72
43	21/10/2005	-0.06	0.00	-0.01	0.00	0.00	-14.77
44	28/10/2005	0.02	0.00	-0.03	0.00	0.00	-16.00
45	04/11/2005	-0.03	0.00	-0.01	0.00	1.00	-24.76
46	11/11/2005	0.06	0.00	0.04	0.00	0.00	-35.42
47	18/11/2005	-0.06	0.00	0.01	0.00	0.00	-41.81
48	25/11/2005	-0.08	0.00	0.01	1.00	0.00	-62.23
49	02/12/2005	0.04	0.00	0.01	1.00	0.00	-68.69
50	09/12/2005	-0.04	0.00	0.01	0.00	0.00	-65.15
51	16/12/2005	0.00	0.00	0.00	0.00	0.00	-60.36
52	23/12/2005	-0.03	0.00	0.01	0.00	0.00	-52.57

Source: Données Thomson Reuters (Bourgeois. 2010).

Table 8. Chronological series of phase II EU ETS: BRENT. GAS. COAL. CSS. CDS

Week	Date	EUA	BRENT	GAS	COAL	CSS	CDS
1	04/01/2008	0.05	0.03	0.01	-0.03	0.00	0.00
2	11/01/2008	-0.02	-0.04	0.04	0.01	-0.20	-0.09
3	18/01/2008	-0.05	-0.04	-0.06	0.01	-0.04	-0.24
4	25/01/2008	0.01	0.04	0.01	-0.02	-0.32	-0.07
5	01/02/2008	-0.07	-0.02	-0.08	0.06	0.19	-0.22
6	08/02/2008	0.06	0.01	0.04	0.00	-0.43	-0.21
7	15/02/2008	0.04	0.01	0.00	0.01	-0.18	-0.22
8	22/02/2008	0.03	0.02	0.00	-0.03	0.43	0.21
9	29/02/2008	-0.01	0.02	0.05	-0.01	-0.24	0.04
10	07/03/2008	0.01	0.02	0.01	-0.03	0.05	0.01
11	14/03/2008	0.02	0.03	0.00	-0.03	0.18	0.14
12	21/03/2008	0.03	-0.01	0.00	0.00	-0.02	0.00
13	28/03/2008	-0.01	0.04	0.00	-0.03	-0.02	0.03
14	04/04/2008	0.07	0.05	0.05	-0.09	-0.92	-0.37
15	11/04/2008	0.04	0.02	0.02	0.01	3.48	0.08
16	18/04/2008	-0.02	0.04	0.00	0.03	-0.37	-0.04
17	25/04/2008	-0.02	0.02	0.09	0.02	-1.09	0.02
18	02/05/2008	-0.03	-0.02	-0.06	0.06	-5.15	0.24
19	09/05/2008	0.00	0.06	-0.14	0.03	7.93	0.04
20	16/05/2008	-0.02	0.02	0.01	0.02	-0.12	-0.02
21	23/05/2008	0.04	0.05	-0.03	0.01	0.45	-0.09
22	30/05/2008	-0.01	-0.03	0.03	0.02	0.39	0.44
23	06/06/2008	0.05	0.08	0.02	0.00	-0.11	0.09
24	13/06/2008	-0.02	0.00	0.05	0.05	-0.17	-0.05
25	20/06/2008	0.01	0.00	0.00	0.02	0.02	-0.06

Source: Données Thomson Reuters (Bourgeois, 2010).

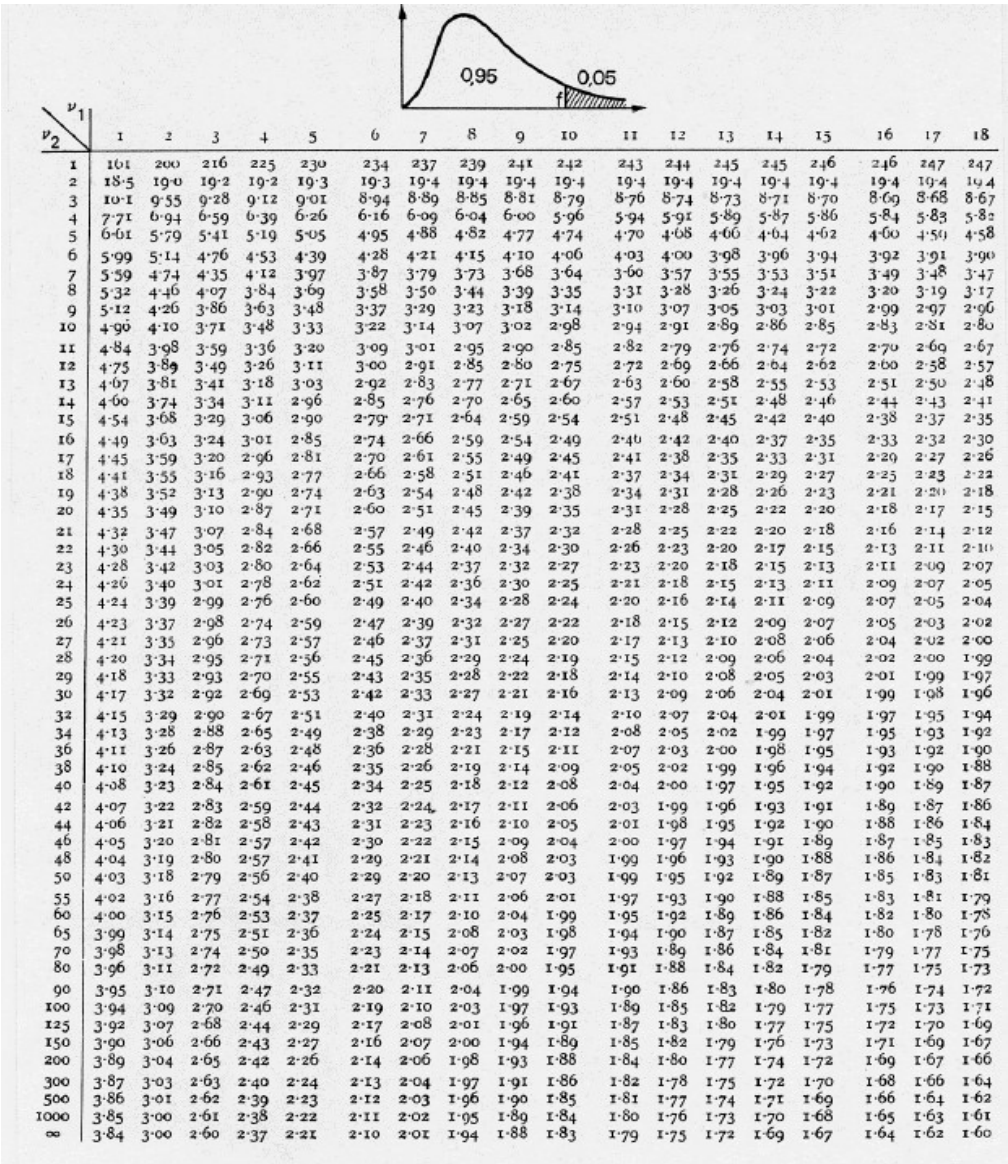
Table 9. Chronological series of phase II EU ETS: DCF, SBF, DEF, DEC, VNS

Week	Date	EUA	DCF	SBF	DEF	DEC	VNS
26	04/01/2008	0.05	0.00	0.00	0.00	0.00	-0.81
27	11/01/2008	-0.02	0.00	-0.05	0.00	0.00	2.48
28	18/01/2008	-0.05	0.00	-0.03	0.00	0.00	2.22

Table 9 (cont.). Chronological series of phase II EU ETS: DCF, SBF, DEF, DEC, VNS

29	25/01/2008	0.01	0.00	0.02	0.00	0.00	3.44
30	01/02/2008	-0.07	0.00	-0.05	0.00	0.00	1.94
31	08/02/2008	0.06	0.00	0.01	0.00	0.00	0.32
32	15/02/2008	0.04	0.00	0.01	0.00	0.00	0.40
33	22/02/2008	0.03	0.00	-0.01	0.00	0.00	0.70
34	29/02/2008	-0.01	0.00	-0.03	0.00	1.00	3.96
35	07/03/2008	0.01	0.00	-0.01	0.00	0.00	0.97
36	14/03/2008	0.02	0.00	-0.02	0.00	0.00	1.49
37	21/03/2008	0.03	0.00	0.04	0.00	0.00	-1.22
38	28/03/2008	-0.01	0.00	0.04	1.00	0.00	-3.64
39	04/04/2008	0.07	0.00	-0.02	0.00	0.00	0.15
40	11/04/2008	0.04	0.00	0.03	0.00	0.00	-2.01
41	18/04/2008	-0.02	0.00	0.00	0.00	0.00	-1.80
42	25/04/2008	-0.02	0.00	0.02	0.00	0.00	-0.59
43	02/05/2008	-0.03	0.00	-0.02	0.00	0.00	-0.96
44	09/05/2008	0.00	0.00	0.02	0.00	0.00	1.14
45	16/05/2008	-0.02	0.00	-0.03	0.00	0.00	1.75
46	23/05/2008	0.04	0.00	0.02	0.00	0.00	-1.65
47	30/05/2008	-0.01	0.00	-0.04	0.00	0.00	1.37
48	06/06/2008	0.05	0.00	-0.02	0.00	0.00	0.57
49	13/06/2008	-0.02	0.00	-0.04	0.00	0.00	-0.55
50	20/06/2008	0.01	0.00	-0.03	0.00	0.00	-2.36

Source: Thomson Reuters Data (Bourgeois, 2010).



ν_2 \ ν_1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	161	200	216	225	230	234	237	239	241	242	243	244	245	245	246	246	247	247
2	18·5	19·0	19·2	19·2	19·3	19·3	19·4	19·4	19·4	19·4	19·4	19·4	19·4	19·4	19·4	19·4	19·4	19·4
3	10·1	9·55	9·28	9·12	9·01	8·94	8·89	8·85	8·81	8·79	8·76	8·74	8·73	8·71	8·70	8·69	8·68	8·67
4	7·71	6·94	6·59	6·39	6·26	6·16	6·09	6·04	6·00	5·96	5·94	5·91	5·89	5·87	5·86	5·84	5·83	5·82
5	6·61	5·79	5·41	5·19	5·05	4·95	4·88	4·82	4·77	4·74	4·70	4·68	4·66	4·64	4·62	4·60	4·59	4·58
6	5·99	5·14	4·76	4·53	4·39	4·28	4·21	4·15	4·10	4·06	4·03	4·00	3·98	3·96	3·94	3·92	3·91	3·90
7	5·59	4·74	4·35	4·12	3·97	3·87	3·79	3·73	3·68	3·64	3·60	3·57	3·55	3·53	3·51	3·49	3·48	3·47
8	5·32	4·46	4·07	3·84	3·69	3·58	3·50	3·44	3·39	3·35	3·31	3·28	3·26	3·24	3·22	3·20	3·19	3·17
9	5·12	4·26	3·86	3·63	3·48	3·37	3·29	3·23	3·18	3·14	3·10	3·07	3·05	3·03	3·01	2·99	2·97	2·96
10	4·96	4·10	3·71	3·48	3·33	3·22	3·14	3·07	3·02	2·98	2·94	2·91	2·89	2·86	2·85	2·83	2·81	2·80
11	4·84	3·98	3·59	3·36	3·20	3·09	3·01	2·95	2·90	2·85	2·82	2·79	2·76	2·74	2·72	2·70	2·69	2·67
12	4·75	3·89	3·49	3·26	3·11	3·00	2·91	2·85	2·80	2·75	2·72	2·69	2·66	2·64	2·62	2·60	2·58	2·57
13	4·67	3·81	3·41	3·18	3·03	2·92	2·83	2·77	2·71	2·67	2·63	2·60	2·58	2·55	2·53	2·51	2·50	2·48
14	4·60	3·74	3·34	3·11	2·96	2·85	2·76	2·70	2·65	2·60	2·57	2·53	2·51	2·48	2·46	2·44	2·43	2·41
15	4·54	3·68	3·29	3·06	2·90	2·79	2·71	2·64	2·59	2·54	2·51	2·48	2·45	2·42	2·40	2·38	2·37	2·35
16	4·49	3·63	3·24	3·01	2·85	2·74	2·66	2·59	2·54	2·49	2·46	2·42	2·40	2·37	2·35	2·33	2·32	2·30
17	4·45	3·59	3·20	2·96	2·81	2·70	2·61	2·55	2·49	2·45	2·41	2·38	2·35	2·33	2·31	2·29	2·27	2·26
18	4·41	3·55	3·16	2·93	2·77	2·66	2·58	2·51	2·46	2·41	2·37	2·34	2·31	2·29	2·27	2·25	2·23	2·22
19	4·38	3·52	3·13	2·90	2·74	2·63	2·54	2·48	2·42	2·38	2·34	2·31	2·28	2·26	2·23	2·21	2·20	2·18
20	4·35	3·49	3·10	2·87	2·71	2·60	2·51	2·45	2·39	2·35	2·31	2·28	2·25	2·22	2·20	2·18	2·17	2·15
21	4·32	3·47	3·07	2·84	2·68	2·57	2·49	2·42	2·37	2·32	2·28	2·25	2·22	2·20	2·18	2·16	2·14	2·12
22	4·30	3·44	3·05	2·82	2·66	2·55	2·46	2·40	2·34	2·30	2·26	2·23	2·20	2·17	2·15	2·13	2·11	2·10
23	4·28	3·42	3·03	2·80	2·64	2·53	2·44	2·37	2·32	2·27	2·23	2·20	2·18	2·15	2·13	2·11	2·09	2·07
24	4·26	3·40	3·01	2·78	2·62	2·51	2·42	2·36	2·30	2·25	2·21	2·18	2·15	2·13	2·11	2·09	2·07	2·05
25	4·24	3·39	2·99	2·76	2·60	2·49	2·40	2·34	2·28	2·24	2·20	2·16	2·14	2·11	2·09	2·07	2·05	2·04
26	4·23	3·37	2·98	2·74	2·59	2·47	2·39	2·32	2·27	2·22	2·18	2·15	2·12	2·09	2·07	2·05	2·03	2·02
27	4·21	3·35	2·96	2·73	2·57	2·46	2·37	2·31	2·25	2·20	2·17	2·13	2·10	2·08	2·06	2·04	2·02	2·00
28	4·20	3·34	2·95	2·71	2·56	2·45	2·36	2·29	2·24	2·19	2·15	2·12	2·09	2·06	2·04	2·02	2·00	1·99
29	4·18	3·33	2·93	2·70	2·55	2·43	2·35	2·28	2·22	2·18	2·14	2·10	2·08	2·05	2·03	2·01	1·99	1·97
30	4·17	3·32	2·92	2·69	2·53	2·42	2·33	2·27	2·21	2·16	2·13	2·09	2·06	2·04	2·01	1·99	1·98	1·96
32	4·15	3·29	2·90	2·67	2·51	2·40	2·31	2·24	2·19	2·14	2·10	2·07	2·04	2·01	1·99	1·97	1·95	1·94
34	4·13	3·28	2·88	2·65	2·49	2·38	2·29	2·23	2·17	2·12	2·08	2·05	2·02	1·99	1·97	1·95	1·93	1·92
36	4·11	3·26	2·87	2·63	2·48	2·36	2·28	2·21	2·15	2·11	2·07	2·03	2·00	1·98	1·95	1·93	1·92	1·90
38	4·10	3·24	2·85	2·62	2·46	2·35	2·26	2·19	2·14	2·09	2·05	2·02	1·99	1·96	1·94	1·92	1·90	1·88
40	4·08	3·23	2·84	2·61	2·45	2·34	2·25	2·18	2·12	2·08	2·04	2·00	1·97	1·95	1·92	1·90	1·89	1·87
42	4·07	3·22	2·83	2·59	2·44	2·32	2·24	2·17	2·11	2·06	2·03	1·99	1·96	1·93	1·91	1·89	1·87	1·86
44	4·06	3·21	2·82	2·58	2·43	2·31	2·23	2·16	2·10	2·05	2·01	1·98	1·95	1·92	1·90	1·88	1·86	1·84
46	4·05	3·20	2·81	2·57	2·42	2·30	2·22	2·15	2·09	2·04	2·00	1·97	1·94	1·91	1·89	1·87	1·85	1·83
48	4·04	3·19	2·80	2·57	2·41	2·29	2·21	2·14	2·08	2·03	1·99	1·96	1·93	1·90	1·88	1·86	1·84	1·82
50	4·03	3·18	2·79	2·56	2·40	2·29	2·20	2·13	2·07	2·03	1·99	1·95	1·92	1·89	1·87	1·85	1·83	1·81
55	4·02	3·16	2·77	2·54	2·38	2·27	2·18	2·11	2·06	2·01	1·97	1·93	1·90	1·88	1·85	1·83	1·81	1·79
60	4·00	3·15	2·76	2·53	2·37	2·25	2·17	2·10	2·04	1·99	1·95	1·92	1·89	1·86	1·84	1·82	1·80	1·78
65	3·99	3·14	2·75	2·51	2·36	2·24	2·15	2·08	2·03	1·98	1·94	1·90	1·87	1·85	1·82	1·80	1·78	1·76
70	3·98	3·13	2·74	2·50	2·35	2·23	2·14	2·07	2·02	1·97	1·93	1·89	1·86	1·84	1·81	1·79	1·77	1·75
80	3·96	3·11	2·72	2·49	2·33	2·21	2·13	2·06	2·00	1·95	1·91	1·88	1·84	1·82	1·79	1·77	1·75	1·73
90	3·95	3·10	2·71	2·47	2·32	2·20	2·11	2·04	1·99	1·94	1·90	1·86	1·83	1·80	1·78	1·76	1·74	1·72
100	3·94	3·09	2·70	2·46	2·31	2·19	2·10	2·03	1·97	1·93	1·89	1·85	1·82	1·79	1·77	1·75	1·73	1·71
125	3·92	3·07	2·68	2·44	2·29	2·17	2·08	2·01	1·96	1·91	1·87	1·83	1·80	1·77	1·75	1·72	1·70	1·69
150	3·90	3·06	2·66	2·43	2·27	2·16	2·07	2·00	1·94	1·89	1·85	1·82	1·79	1·76	1·73	1·71	1·69	1·67
200	3·89	3·04	2·65	2·42	2·26	2·14	2·06	1·98	1·93	1·88	1·84	1·80	1·77	1·74	1·72	1·69	1·67	1·66
300	3·87	3·03	2·63	2·40	2·24	2·13	2·04	1·97	1·91	1·86	1·82	1·78	1·75	1·72	1·70	1·68	1·66	1·64
500	3·86	3·01	2·62	2·39	2·23	2·12	2·03	1·96	1·90	1·85	1·81	1·77	1·74	1·71	1·69	1·66	1·64	1·62
1000	3·85	3·00	2·61	2·38	2·22	2·11	2·02	1·95	1·89	1·84	1·80	1·76	1·73	1·70	1·68	1·65	1·63	1·61
∞	3·84	3·00	2·60	2·37	2·21	2·10	2·01	1·94	1·88	1·83	1·79	1·75	1·72	1·69	1·67	1·64	1·62	1·60

Figure 2. Fisher Variable.

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