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José Raymundo Serrano Marín
Wroclaw University of Economics

MULTI-FACTOR MODELS FOR CARBON RISK MEASUREMENT IN POLISH ENTERPRISES IN THE ENERGY MARKET

Abstract: Carbon risk has serious implications for the activities of management, investors, creditors and other stakeholders in the financial world. This article presents a method enabling the measurement of carbon risk, using an example of the largest Polish corporations operating in the energy market which are theoretically highly exposed to carbon risk due to their high consumption of combustible fuels in the process of producing energy.

Keywords: carbon risk, Polish energy market, public limited companies.

1. Introduction

In the past, the approach to climate change was as an issue of social and corporate responsibility. However in the last decade it has become an important and significant risk challenge for corporations and investors whose exposure to climate risk depends on the economic sector, geographic location and legal constrains around them. Awareness of climate risk is increasing rapidly, for instance in 2007 Lehman Brothers conducted research in which they stated "we saw climate change as a slow but powerful force that, like globalization, technological change, or population ageing, inexorably stands to shape, possibly quite fundamentally, the economic environment in which companies operate" [Llewellyn & Chaix 2007, p. 1].

Since the end of the last decade, many policies and laws have been enacted in the name of climate change, with the aim to reflect the cost of pollution in the production process, also called carbon cost. Thus a new source of risk for financial assets has emerged, which is known as carbon risk. Carbon risk arises from the obligation to comply with any carbon policy that is likely to have a material effect on the financial performance of economic entities and any financial asset in general [Labatt & White 2007, p. 11].

In contrast to the classic CAPM model, which captures all the market risk in a single risk factor, in this article a multi-factor model with formerly identified indexes is proposed as an option to identify and measure carbon risk in asset valuation.

Carbon risk has important implications for managers, investors, creditors and other stakeholders in the financial world. This article presents an opportunity to explore and measure carbon risk in the largest Polish energy corporations which operate in a market that in theory is highly exposed to carbon risk as a consequence of the high consumption of combustible fuels in energy production. This suggests that Polish companies engaged in energy production are highly exposed to carbon risk.

2. Carbon risk

A new type of risk emerged after the Kyoto protocol came into force in 2005, which thus far is considered to be the most important agreement on Green House Gases (GHG). On January 1st 2005, the European Union launched the European Union´s Emission Trading Scheme (EU ETS) with the aim to help EU Member States to achieve compliance with their commitments under the Kyoto Protocol. This is the first (and most important) legally binding international trading system for CO_2 emissions in the world, and today it represents the largest carbon trading scheme in operation. It currently covers more than 12,000 installations under legislation [Brohé, Eyre & Howarth 2009, p. 107].

The EU ETS includes the 27 member states of the European Union which altogether make up nearly 63% of the Annex I participant countries of the Kyoto protocol [Europa Press Releases Rapid 2010]. The main economic sectors and activities covered by the European Union Scheme include installations[1] from combustion plants, mineral and oil refineries, coke ovens, metal ore roasting or sintering, pig iron or steel, cement clinker or lime, glass including glass fibre, ceramic products by firing, pulp, paper and board, and other opted-in activities. Additionally on January 13th 2009 the European Union published in the Official Journal, under the Directive 2008/101/EC, new legislation which incorporates aviation into the EU emissions trading scheme (EU ETS) from January 1st 2012 [Brohé et al. 2009].

2.1. An overview of the Polish energy market

As a member of the European Union, Poland has to comply with the EU ETS, and therefore different industries and companies within Polish jurisdiction are required to meet the regulations imposed by the EU ETS. In Poland more than 95% of the electricity generated comes from the combustion of fossil fuels – mainly coal and lignite [PGE, 2009]. The world coal organization ranked Poland as the second country in the world where coal is the main source used to produce electricity (92%),

[1] For the scope of the EU ETS, installations are referred to as a stationary technical units where one or more activities listed in Annex I of the directive 2004/101/EC are carried out, and any other directly associated activities which have a technical connection with the activities carried out on that site, and which could have an effect on emissions and pollution. Additionally, to be classified as installations, these units must have a rated thermal input exceeding 20 MW (except hazardous or municipal waste installations) [Brohé et al. 2009, pp. 113-119].

just behind South Africa with 93%. What it is more, it is believed that in the short and midium term the importance of coal in the generation of electricity will continue worldwide with a participation of 44 percent. The high reliance on coal for energy production in Poland is explained primarily by the vast domestic deposits of coal that the country has: in 2010 it was ranked as the ninth highest hard coal producer in the world and the largest coal producer in Europe [World Coal Association 2011]. Additionally, natural gas, oil and renewable sources have a low participation as fuels in the national electricity production, although the use of natural gas has been increasing in the last few years.

For the purpose of this analysis, the three largest public energy providers in Poland (Polska Grupa Energetyczna, Tauron Polska Energia and Enea) have been selected. Polska Grupa Energetyczna is the company leader in energy production in Poland with a market share of 40 percent. Tauron Polska Energia is the second largest Polish energy producer with a market share of 15 percent, while Enea S.A. is in third place with a market share of 8 percent. These three companies accounted for 66% of the total energy produced in Poland in 2009 [BOS 2009, p. 4].

Under the scope of the EU ETS, the companies selected for this research are classified as installations[1] with a thermal input exceeding 20 MW, thus the companies selected face the restrictions of the EU ETS. Therefore they represent a potential case for measuring carbon risk in asset valuation, since they have to include the cost of carbon certificates[2] both in investment decisions and in daily business operations.

2.2. Measuring carbon risk

In financial literature, carbon risk is a relatively new concept which began to be developed and studied after the first Cap-and-Trade Schemes were launched in 2005 (EU ETS). It can be defined as the sensitivity of changes in stock returns to carbon returns. It is a manifestation of the regulatory risk. In other words it arises from the obligation of corporations to comply with any carbon policy that is likely to have a substantial effect on the financial performance of any entity covered by such a treaty [Labatt & White 2007, p. 11].

So far there have not been many approaches to the measurement and quantification of carbon risk and its effects on asset valuation. For instance, Carbon Trust and Mckinsey [2008] proposed a methodology to introduce carbon risk into the value of a company by modifying and adjusting cash flows, and by doing that to reflect the carbon risk related to the operations enterprises. The pitfall of this approach is that the estimations of the expected cash flows may not be properly estimated and thus the valuation results may be unrealistic.

Another approach considers the effect of carbon risk in the Weighted Average Cost of Capital (WACC), by adjusting the cost of equity using a multi-factor model under the assumptions that carbon risk is a systematic factor as well as market risk.

[2] When they are not granted and they have to be bought during the EU ETS phase III.

Thus the resulting cost of capital, once carbon risk is included, is called by Bassen et al. (2010), the carbon adjusted cost of capital [Bassen, Koch and Rothe 2010, p. 2-4]. Actually this approach is based on a multi-factor model with a prior specified set of portfolios affecting the returns-generating process. More specifically it is based on the model developed by Fama and French [1993] where they explain returns and expected returns, in both bonds and stocks, by considering different return portfolios, besides the market portfolio of stocks, to represent the influences or indexes ($I_j s$) affecting the return-generating process [Damodaran 2009].

There are different financial models that measure non-diversifiable risk (market risk), either as a single market risk model (CAPM), or as multi-factor risk models that integrate the total non-diversifiable risk which is believed to explain the return-generating process. Multi-factor models can be classified into three main categories; the first one hypothesizes a set of macroeconomic indexes, the second one a set of company characteristics, and the third one specifies a set of portfolios as the indexes [Elton et al. 2007, pp. 371-373].

2.3. The hypothesis

The null hypothesis established for this analysis is that the returns on the three selected companies are driven by both market risk and carbon risk. Thus the beta coefficient on the carbon factor is statistically significant different than zero.

If the null hypothesis is confirmed, the returns on Polska Grupa Energetyczna, Tauron Polska Energia and Enea S.A. are affected by changes of carbon prices and therefore an additional risk premium has to be added to the market risk premium.

Subsequently, adding carbon risk into the cost of equity will allow investors and managers to include carbon risk when making investment valuations and setting asset prices by considering a higher risk premium in the case of high-emitting installations or lower risk premium for those with low emissions.

3. Risk measurement model: a two-factor model for carbon risk measurement

In order to measure the carbon risk of the selected sample and to test the previously established hypothesis, a two-factor model was developed based on the following assumptions:

- Companies (under the EU ETS called installations[1]) do not have access to free allocation of allowances[3].
- Carbon risk is systematic [Bassen et al. 2010, p. 4].
- Companies operating under regulations from the EU ETS are not able to pass on the cost of carbon emission to customers.

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[3] European Union allowances (EUA´s) represent the rights to emit one metric ton of CO_2 equivalent granted under the EU ETS (CO e).

3.1. Influences affecting the return-generating process

In order to determine whether or not the null hypothesis should be accepted or rejected it has been assumed that both market risk and carbon risk factors should be considered as the influences affecting the return-generating process for PGE, TPE and Enea.

The WIG index was taken as the market portfolio in order to measure the market risk. The index comprises all the companies listed on the Warsaw Stock Exchange Main List (these that meet the base eligibility criteria), and thus in theory it applies the portfolio diversification principle [Warsaw Stock Exchange 2010, p. 7].

The Carbix index was taken as a reference of carbon risk factor. The index is developed by the European Energy Exchange, the leading energy exchange in Europe which operates market platforms for trading in power, natural gas, CO_2 emission allowances and coal [European Energy Exchange 2011, p. 1]. The Carbix index provides a reference price for emission allowances which is published a few minutes after the auctions take place on each exchange day, thus it provides a reliable and transparent spot market reference on Europe's CO_2 (EUA´s) [European Energy Exchange 2011, p. 11].

Given the above assumptions and the specified influences affecting the return-generating process, the two-factor model that should explain the return of the selected sample is as follows:

$$E(R_j) = R_f + \beta_m(E(R_m) - R_f) + \beta_c(E(R_c) - R_f) \qquad 2.1$$

where: R_f – risk free rate.
$E(R_j)$ – expected return on company *j*.
β_m – beta relative to changes in market portfolio to stock returns.
$E(R_m)$ – expected return on a portfolio with beta equal to 1 in market factor, and 0 in all other factors.
β_c – beta relative to changes in carbon returns to stock returns.
$E(R_c)$ – expected return on a portfolio with beta equal to 1 in carbon factor, and 0 in all other factors.

Condition for the model: The Carbon beta coefficient differs from zero, $\beta_c \neq 0$.

3.2. Regression analysis

A simple Ordinary Least Squares regression analysis was carried out in order to confirm or reject the stated hypothesis. The sample data covered the period between July 7th 2010 to September 30th 2011; this time interval covers from the day all three sampled companies were listed on the Warsaw Stock Exchange to the most recent day that it was possible to be considered in order to prepare this research paper. The sample frame covers 315 daily return observations of the three dependent variables (PGE, TPE and Enea), as well as two independent variables (WIG and CARBIX). The general formula used to perform the OLS regression analysis is as follows:

$$r_i = \alpha_i + \beta_{iM} r_M + \beta_{iC} r_C + \varepsilon_i \qquad 2.2$$

where: r_i – daily arithmetical returns for company *i*.
r_M – daily arithmetical returns for WIG.
r_C – daily arithmetical returns for Carbix (EU emission allowances index).
β_{iM} – market risk measure.
β_{iC} – carbon risk measure.

3.3. Regression analysis results

The regression analysis performed on the returns on PGE, TPE and Enea for the sampled period covering the time from July 7th 2010 to September 30th 2011 are presented in Annexes 1, 2 and 3. The results indicate that market risk is present and drives the returns of the three analyzed Polish companies, a result that so far is not surprising. However, the results also suggest that during the sampled period neither the returns of Polska Grupa Energetyczna, Tauron Polska Energia nor Enea SA were influenced by carbon risk.

Based on the results from the regression analysis, the only systematic risk affecting the return performance of these companies was the market risk. Thus, the null hypothesis at this research, which states that "the returns on the three selected companies are driven by both market risk and carbon risk, thus the beta coefficient on carbon factor is statistically significant different than zero", is rejected.

4. Analysis

In order to identify the reason why the carbon factor coefficient was not statistically different than zero, it is necessary to remember that under the assumptions on which the two-factor model was built, when companies have to acquire European Union Allowances[3] (EUA´s) or equivalent units at market price (without free allocation), they face the risk of price changes on these instruments (EUA´s) and therefore both low-emitters and high-emitters are exposed to carbon risk.

However, when analyzing the first and the current second trading period under the European Emission Trading Scheme (EU ETS), it can be observed that the financial markets for EUA´s have not been efficient. For instance, during the first trading period from January 2005 to December 2007, allowances were not only allocated freely to participating entities, but they were also over allocated; thus installations over benefited from them which brought the EU ETS into crisis and caused the prices of EUA´s to basically fall through the floor. This situation was known as windfall profits [Streeter et al. 2010, p. 335].

While the first period was called the 'learning by doing' period by the European Union Authorities, for the second trading period the European Community (EC) reduced the proposed allocation for individual Member States by an average of

10.5%, and allowed countries to auction up to 10% of total emission allocations. However the windfall profit of the First Phase has been difficult to solve in the second one, mainly due to the fact that governments refused to use auctions as an allocating mechanism [Streeter et al. 2010, pp. 227, 335]. Besides, currently at the second trading period, installations within the scheme are being granted quotas that basically cover their total emissions.

Given the development of the EU ETS in the first and in the current (second) trading phase, it is not surprising that during the sampled period none of the companies within the sample were subject to carbon risk, and therefore their carbon factor betas were not statically significant enough to include carbon risk as a real source of risk.

In December 2008 ministers of the EU agreed that from 2013 all EU power producers (installations) would be forced to pay for permits to emit each ton of carbon dioxide. However, an exception was made for Poland and other Eastern European countries in that they were allowed to grant up to 70% of those permits for free in 2013 and gradually reduce them to zero by 2020[4].

Additionally, on 14th July 2010 the European Commission approved the proposal for a regulation governing the auctioning of emission allowances for the third trading period. The draft regulation states that in 2013 at least half of the total volume of allowances is expected to be auctioned and progressively replace the free allocation as the main method for allocating allowances to all EU ETS sectors, except for aviation for which 15% of allowances will be auctioned in 2012 and this proportion will stay the same in subsequent years [Europa Press Releases RAPID 2010].

Due to these new changes in the EU ETS regulations, it is expected that from 2013, when the third phase begins, the auction process for allocation will finish with windfall profits and enhance the efficiency in the carbon trading market, thus providing more reliable financial data and indicators that contribute to the assessment and measurement of carbon risk and its implications for asset valuation and risk management.

5. Conclusions

Carbon risk emerged in 2005 after both the Kyoto protocol and the European Union´s Emission Trading Scheme (EU ETS) came into force. It is defined as the sensitivity of changes in carbon returns to stock returns. So far there have not been many approaches to measure and quantify carbon risk and its effect on asset valuation, thus multi-factor models represent an important financial tool to value assets under the belief that the return-generating process is affected by more than one factor.

With the aim to measure carbon risk, a two-factor model was used with market risk and carbon risk as the prior identified risk factors. The results from the regression

[4] This applied to all power plants that were physically initiated by the end of 2008 [EurActiv 2010, pp. 7-11].

analysis showed that during the sampled period the returns on the three largest Polish energy producers (PGE TPE and Enea) were affected by the market factor, but not the carbon factor. These results imply that during the sampled period:

(1) Companies in the sample were not affected by carbon risk,

(2) Carbon risk did not represent a source of risk for these companies, and thus,

(3) There was no evidence to consider carbon risk to have a material effect on the investment decisions of the analyzed companies.

It is also important not to overestimate or misinterpret the results, because they only suggest that during the sampled period, for the group of companies selected and with the application of a two-factor risk model developed for this analysis, carbon risk factor was not statistically significant enough to assume that it is a real source of risk for these companies. Therefore more research in the field is needed in order to provide more reliable conclusion about carbon risk.

Annexes

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Model 1: OLS estimates using the 315 observations 10/07/06-11/09/19
Dependent variable: PGE

     VARIABLE       COEFFICIENT        STDERROR      T STAT    P-VALUE

  const                2.60631E-05      0.000670141   0.039    0.96900
  WIG                  1.08910          0.0582326    18.703   <0.00001 ***
  CARBIX               0.0170440        0.0352633     0.483    0.62920

  Mean of dependent variable = -4.11579e-005
  Standard deviation of dep. var. = 0.0174049
  Sum of squared residuals = 0.0440296
  Standard error of residuals = 0.0118794
  Unadjusted R-squared = 0.537118
  Adjusted R-squared = 0.53415
  F-statistic (2, 312) = 181.019 (p-value < 0.00001)
  Durbin-Watson statistic = 2.07919
  First-order autocorrelation coeff. = -0.0460013
  Log-likelihood = 950.92
  Akaike information criterion (AIC) = -1895.84
  Schwarz Bayesian criterion (BIC) = -1884.58
  Hannan-Quinn criterion (HQC) = -1891.34
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Annex 1. Regression analysis results for Polska Grupa Energetyczna

Source: [Gretl program 2011]. Data retrieved from Bossa.pl.

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Model 2: OLS estimates using the 315 observations 10/07/06-11/09/19
Dependent variable: TPE

     VARIABLE       COEFFICIENT        STDERROR      T STAT    P-VALUE

  const                0.000185313      0.000727023   0.255    0.79897
  WIG                  0.807322         0.0631754    12.779   <0.00001 ***
  CARBIX              -0.0112079        0.0382565    -0.293    0.76974

  Mean of dependent variable = 0.000157991
  Standard deviation of dep. var. = 0.0159078
  Sum of squared residuals = 0.0518214
  Standard error of residuals = 0.0128878
  Unadjusted R-squared = 0.347831
  Adjusted R-squared = 0.34365
  F-statistic (2, 312) = 83.2017 (p-value < 0.00001)
  Durbin-Watson statistic = 2.02791
  First-order autocorrelation coeff. = -0.0204387
  Log-likelihood = 925.257
  Akaike information criterion (AIC) = -1844.51
  Schwarz Bayesian criterion (BIC) = -1833.26
  Hannan-Quinn criterion (HQC) = -1840.02
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Annex 2. Regression analysis results for Tauron Polska Energia

Source: [Gretl program 2011]. Data retrieved from Bossa.pl.

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Model 3: OLS estimates using the 315 observations 10/07/06-11/09/19
Dependent variable: ENEA

     VARIABLE       COEFFICIENT        STDERROR      T STAT   P-VALUE

  const               -0.000152123      0.000907904  -0.168   0.86704
  WIG                  0.571221         0.0788933     7.240  <0.00001 ***
  CARBIX              -0.0274380        0.0477746    -0.574   0.56616

  Mean of dependent variable = -0.000153038
  Standard deviation of dep. var. = 0.0173465
  Sum of squared residuals = 0.0808152
  Standard error of residuals = 0.0160942
  Unadjusted R-squared = 0.144654
  Adjusted R-squared = 0.139171
  F-statistic (2, 312) = 26.3824 (p-value < 0.00001)
  Durbin-Watson statistic = 1.9942
  First-order autocorrelation coeff. = 0.0021551
  Log-likelihood = 855.27
  Akaike information criterion (AIC) = -1704.54
  Schwarz Bayesian criterion (BIC) = -1693.28
  Hannan-Quinn criterion (HQC) = -1700.04
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Annex 3. Regression analysis results for Enea S.A.

Source: [Gretl program 2011]. Data retrieved from Bossa.pl.

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MODELE WIELOCZYNNIKOWE DO POMIARU RYZYKA RYNKU WĘGLA W POLSKICH PRZEDSIĘBIORSTWACH Z RYNKU ENERGII

Streszczenie: Ryzyko rynku węgla ma istotne znaczenie dla podejmowania działań przez zarządzających, inwestorów, kredytodawców oraz innych interesariuszy świata finansów. W artykule została pokazana metoda umożliwiająca kwantyfikację ryzyka rynku węgla na przykładzie największych polskich spółek z rynku energii, które teoretycznie są najbardziej narażone na ryzyko rynku węgla ze względu na wysoką konsumpcję paliw palnych w procesie produkcji energii.

Słowa kluczowe: ryzyko rynku węgla, polski rynek energii, spółki publiczne.