CARBON AND INFLATION

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Abstract: This paper investigates whether European Union Allowances (EUAs) can serve as an inflation hedge for two economic areas, four euro countries and two non-euro countries. The Extended Fisher Hypothesis is tested and the evidence shows a strong positive relationship between EUA returns and the unexpected inflation component in all the economic areas or countries analysed, except for the US. Therefore, EUAs are able to provide a hedge against unanticipated inflation rates.

Keywords: EUAs, HICP, inflation hedge

JEL Codes: G10, G11, G19

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1. Introduction

The European Union Emissions Trading System (EU ETS) came into force in 2005 as a market-based mechanism whereby the GHG emissions of the most emitting industrial sectors in the European Union were capped. Under the EU ETS, companies receive or buy emission allowances (called European Union Allowances or EUAs) in order to comply with their GHG emission objectives. The EU ETS has been organized into trading periods or phases. During Phase I (2005-2007), almost all the allowances were given to companies for free. However, in Phase II (2008-2012) the cap was lowered by 6.5% compared to 2005 and the proportion of freely allocated allowances fell slightly. During Phase III (2013-2020), the supply of allowances has been decreasing by a linear reduction factor of 1.74% of the average total quantity of allowances issued annually in Phase II with the aim of continuing the reduction at an annual rate of 2.2% from 2021 onwards. Furthermore, the European Commission in 2014 postponed the auctioning of 900 million allowances, which were transferred to a Market Stability Reserve that began to operate in January 2019 in order to address the current surplus of allowances.[1]

The above-mentioned facts explain the gradual reduction in the number of available allowances since 2005, which is likely one of the main reasons for the significant rise in the price of European Union Allowances observed in recent years. For example, the ICE EUA 2018 December futures contract that traded at

[1] See https://ec.europa.eu/info/energy-climate-change-environment_en for more details on the European Commission's efforts to fight against climate change at the European Union and international levels (last accessed on 13 March 2020).

8.62 €/tonne in January 2013, closed at 24.26 €/tonne when the contract matured in December 2018, which means that the price tripled in six years.

The climb in EUA prices, coupled with low interest rates, have renewed interest in investing in EUA assets, directly or indirectly, through futures, options or ETFs. The effectiveness of EUAs as a hedge against inflation is of interest to EUA investors and/or portfolio managers, who could invest in EUAs while protecting themselves from inflation-related losses in purchasing power. On the one hand, the literature is extensive on the effectiveness of common stocks, gold, fixed income securities and real estate as hedges against inflation risk. Arnold and Auer (2015) make a comprehensive review of the state of scientific knowledge on the inflation hedging properties of these major asset classes and conclude that there is still no consensus on the subject because sample, data and methodology issues preclude the strict comparison of most studies. On the other hand, the literature on the link between agricultural commodities and inflation is more recent and sparser. Salisu et al. (2019) make a cursory review of the empirical evidence focused on commodity indexes and agricultural commodities and find that both of them provide some protection against inflation risks.

However, as far as we know, the question of whether EUAs act as an inflation hedge has only been addressed in the paper by Medina and Pardo (2013). They investigate some stylized facts of EUA returns and their results indicate that EUAs do not behave like common commodity futures or financial assets, concluding that EUAs are a new asset class. Regarding the ability of EUAs to act as an inflation hedge, they take the free risk interest rate (the one month Euribor rate) as the expected inflation, leaving the unexpected inflation as the difference between the observed inflation (European Union Harmonized Index of Consumer Prices) and the expected inflation. They obtain a positive Spearman's contemporaneous cross-correlation coefficient between nominal EUA returns and the monthly unexpected inflation rates for the 2008, 2009 and 2010 EUA futures contracts, which is interpreted as meaning that EUA assets can help to hedge against inflation in the euro zone. This paper extends the previous study by Medina and Pardo (2013) by applying the Extended Fisher Hypothesis, proposed by Fama and Schwert (1977), to investigate the relation between EUA nominal returns and the expected and unexpected inflation rates. Both inflation rates have been obtained from Autoregressive Distributed Lag models. Furthermore, this work studies whether EUAs can serve as inflation hedges from a global perspective, given that we analyse this possibility by taking into account the Harmonized Index of Consumer Prices (HICP) for two economic areas, four euro countries and two non-euro countries. The rest of the paper is organised as follows. Section 2 describes the data and the methodology, section 3 presents the results and section 4 concludes.

2. Data and methodology

2.1. Data

We have used daily settlement prices of the EUA December futures contracts traded at ICE ECX, which have been obtained directly from the website of the Intercontinental Exchange (theice.com). Although the ICE ECX futures market trades several maturities, the ICE ECX December futures contract is widely considered as the international benchmark for the EUA price. Each EUA represents an entitlement to emit one tonne of carbon dioxide equivalent gas.

A continuous time series has been constructed by rolling over, on the last trading day, the time series of the December futures contracts. Then, we have taken the natural logarithm of the ratio of two daily consecutive prices to calculate the daily EUA continuously compounded return. For the day following the delivery date, the return has been obtained as the ratio of the two consecutive closing prices of the new nearby December futures contract, in order to avoid artificial jumps. Finally, we have summed the daily returns of the same month to get the EUA monthly return. This procedure provides a return similar to what would have been obtained if we had followed a buy-and-hold strategy on the nearby EUA December futures contracts.

Figure 1 displays the daily evolution of the continuous time series for the analysed period. The excess of allowances in Phase I and the inability to use them in Phase II provoked a dramatic fall in EUA prices, which plummeted to €0.03 in December 2007 (see Alberola and Chevalier, 2009). The EUA price soared in Phase II to peak at €29.33, but fell again at the end of this period due to the economic crisis and the growth of wind and solar electricity production (see Koch et al. 2014). Finally, the price rallied in Phase III from €2.75 in April 2013 to €27.53 in April 2019, mainly attributable to the reduction in the number of auctions and to increases in energy demand (see Galán-Valdivieso et al. 2018).

[Please Insert Figure 1]

It is important to remark that Phase I allowances could not be banked for use in Phase II. This fact means there are structural differences between the returns in these phases. As banking activity was allowed between Phase II and Phase III, this paper is based only on these two periods, discarding the data from Phase I. Therefore, the sample data goes from January 2008 to April 2019, providing us with 136 monthly observations.

Next, we have used eight Harmonized Indices of Consumer Prices (HIPC) obtained from Eurostats. Specifically, we have considered: (i) the official aggregate HICP for the European Union that takes into account all the European Union Members at any given point in time (henceforth EU); (ii) the official aggregate HICP for the European Economic Area, which includes all the European Union Members plus Iceland and Norway (henceforth EEA); (iii) the national Harmonized Indices of Spain, Germany, France and Italy, all of them belonging to the euro zone; and (iv) the Harmonized Indices of two non-euro countries, the United Kingdom (UK) and the United States (US).[2]

Finally, to estimate both the monthly expected and unexpected inflation rates, we have used the One-month Euribor, the One-month GPB Libor, and the One-month US dollar Libor interest rates as the money market references for euro countries, the UK and the US, respectively. The interest rates have been obtained from Global-Rates.com and make reference to the first rate of the month t that will be applied for a deposit of one month to maturity. Furthermore, in order to

[2] The HICP is a monthly statistic that is designed as a Laspeyres-type index to measure changes in the prices of goods and services that households acquire for consumption. See https://ec.europa.eu/eurostat/web/hicp for a comprehensive overview of methods that are used in the compilation process to calculate the HICP (last accessed on 13 March 2020).

maintain coherence with the EUA buy-and-hold strategy previously described, both the changes in inflation and the interest rates of the money market references have been continuously compounded on a monthly basis.

2.2. Methodology

We have studied the extended Fisher hypothesis proposed by Fama and Schwert (1977). Specifically, we have estimated the conditional expected value of the EUA return as a function of both the expected value and the unexpected inflation. The regression model is as follows:

$$EUA_t = \alpha_k + \beta_k E_{t-1}(\pi_{k,t}) + \gamma_k[\pi_{k,t} - E_{t-1}(\pi_{k,t})] + \varepsilon_{k,t} \qquad (1)$$

where EUA_t is the monthly EUA return; k indicates the area or country (EU, EEA, Spain, Germany, France, Italy, UK and US); $E_{t-1}(\pi_{k,t})$ is the monthly expected inflation for area or country k; and $[\pi_{k,t} - E_{t-1}(\pi_{k,t})]$ is the monthly unexpected inflation. Following Fama and Schwert (1977), EUA is a perfect hedge against expected inflation (unexpected inflation), if β_k (γ_k) is not significantly different from 1.

The results of the inflation hedging test rest on an accurate estimation of the expected and unexpected inflation. Following the idea suggested by Gultekin (1983, p.59), we have estimated an Autoregressive Distributed Lag (ARDL) model that include lags of both the dependent variable and the explanatory variables as regressors. In our case, the dependent variable is the observed inflation for each country while the independent variable is the chosen benchmark from money market returns. The model we have used to estimate the expected inflation is:

$$\pi_{k,t} = \alpha_0 + \sum_{i=1}^{p} \beta_i \, \pi_{k,t-i} + \sum_{j=0}^{q} \gamma_j \, R_{t-j} + \epsilon_{k,t} \quad (2)$$

where R_t makes reference to the Euribor or Libor rates. This ARDL(p,q) model assumes that inflation depends on *p* past changes in the inflation rate and on the current and *q* past changes in the monthly interest rates. The inflation forecasts from ARDL models have been chosen as estimates of the expected inflation, while the forecast errors have been used as the unexpected component of monthly inflation rates.[3] All the regression models carried out in this study have been estimated using both ordinary least squares and the Newey and West correction in order to account for heteroskedasticity and serial correlation problems.

3. Results

Firstly, we have obtained inflationary expectations from ARDL models following the Akaike information criterion. Then, we have used the predictions from the best ARDL model for each area/country as the expected inflation rates, and the prediction errors as the unexpected inflation rates. Next, we have performed a Spearman's rank correlation analysis between the EUA futures contract returns and the series of expected and non-expected inflation rates. The cross-

[3] We have also regressed the EUA returns on lagged monthly observed inflation rates. Specifically, we have estimated the best regression models following the Akaike information criterion and the results indicate that the explanatory power of the observed inflation rates is null or very low in all the areas and countries. These results are not included for the sake of brevity, but they are available from the authors upon request.

correlation coefficients between the EUA returns and the series of expected inflation rates are non-significantly different from zero. However, the cross-correlation coefficients between EUA returns and the unexpected inflation rates for EU, EEA, Spain, Germany, France and UK are positive and significant at the conventional levels of testing, suggesting that the unexpected component of inflation could be easily hedged with EUAs. This lends support to previous findings obtained by Medina and Pardo (2013) for the European Union (EU) and the European Economic Area (EEA), although the empirical measure of the unexpected inflation they used is different.

Secondly, we have tested the extended Fisher hypothesis for each area/country. In order to ensure robustness, three model selection criteria have been applied: the Akaike information criterion (AIC), the Schwarz criterion (SC) and the Hannan-Quinn (HQ) criterion. The ARDL model for each area/country has been selected on the basis of the minimum value of the chosen criterion and the results are presented in Panels A, B and C of Table 2. The column ARDL(p,q) indicates the model selected for each criterion where p indicates the number of lags of the observed inflation and q stands for the number of lags of the monthly interest rates. Panels B and C present only the results for the ARDL models that do not coincide with the models that have been previously chosen following the AIC.

[Please Insert Table 2]

The goodness-of-fit coefficients in Table 2 seem very low for some countries. One possible reason could be the omission in the regression model of additional risk factors that can cause variation in nominal EUA returns, such as energy prices, weather conditions, data releases and/or regulatory decisions (see Chapter 5 in Ellerman et al. 2010). However, following Demary and Voigtländer (2009), microstructure effects dominate the effects of macroeconomic fundamentals at the monthly frequency, the reason for which is that private information arrives more frequently compared to macro news (e.g. inflation projections).

Regarding the estimates of the inflation coefficients, the expected inflation rates are not significantly different from zero in all the areas and countries at the conventional levels. Note that the coefficient for Germany is significant at the 10% level in Panel A, but is not so in Panels B and C. Furthermore, the results in all the Panels show a strong positive relationship between EUA nominal returns and the unexpected inflation rates in all the cases, except for the US. The significant unexpected inflation coefficients are large and they are far from a one-to-one correspondence, just as the extended Fisher Hypothesis stated. However, following Arnold and Auer (2015), although the EUA does not provide a perfect hedge, a stable positive return-inflation relation can still make the EUA valuable, because adequate hedge ratios theoretically allow its use as an effective hedge.

4. Conclusions

This paper investigates the ability of EUAs to hedge for inflation in two economic areas and six countries. Firstly, following three criteria, we have estimated inflationary expectations from autoregressive distributed lag models and, secondly, we have applied the extended Fisher hypothesis proposed by Fama and Schwert (1977) to study the relation between EUA nominal returns and the expected and unexpected inflation rates. The results indicate that EUA returns ignore the expected but not the unexpected component of the monthly inflation rates in all the areas and countries, except for the US. The positive and marked relationship observed between EUA nominal returns and unanticipated changes in purchasing power suggests that portfolio managers can use EUAs to shield their portfolios from the ravages of unexpected inflation.

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Figure 1. EUA price

This figure displays the daily evolution of the EUA December futures contract of the continuous time series from April 22, 2005 to May 14, 2019. The prices comprise Phase I (2005-2007), Phase II (2008-2012) and Phase III (2013-2020).

Table 1. Spearman's rank correlation coefficients

This table shows the Spearman's rank correlation coefficients (*ρ*) and their p-values between the EUA futures contract returns and the series of the expected and non-expected inflation rates. $E_{t-1}(\pi_{k,t})$ is the monthly expected inflation and $\pi_{k,t} - E_{t-1}(\pi_{k,t})$ is the monthly unexpected inflation where *k* indicates the area or country (EU, EEA, Spain, Germany, France, Italy, UK and US). Sample period goes from January 2008 to April 2019.

	$E_{t-1}(\pi_{k,t})$		$\pi_{k,t} - E_{t-1}(\pi_{k,t})$	
Area/Country	*ρ*	p-value	*ρ*	p-value
EU	-0.047	0.590	0.267	0.002
EEA	-0.042	0.629	0.262	0.002
SPAIN	0.007	0.934	0.202	0.018
GERMANY	0.201	0.019	0.186	0.030
FRANCE	0.149	0.082	0.234	0.006
ITALY	0.081	0.348	0.136	0.115
UK	0.122	0.158	0.252	0.003
US	0.050	0.561	0.124	0.151

Table 2. EUA returns and expected and unexpected inflation

Panels A, B and C present the estimates of equation (1) following the Akaike info criterion (AIC), the Schwarz criterion (SC) and the Hannan-Quinn (HQ) criterion to predict inflation from ARDL models, respectively. The column ARDL(p,q) indicates the model selected for each criterion where p indicates the number of lags of the observed inflation and q stands for the number of lags of the monthly interest rates; *α, β,* and *γ* show the estimates of equation (1); R^2 denotes the coefficient of determination, and Adj-R^2 is the adjusted coefficient of determination. Sample period goes from January 2008 to April 2019.

Area/Country	ARDL(p,q)	α	p-value	β	p-value	γ	p-value	R^2	Adj-R^2
Panel A: AI Criterion and estimates of Equation (1)									
EU	4,1	0.459	0.766	-3.992	0.541	10.611	0.021	0.073	0.059
EEA	4,1	0.415	0.788	-3.670	0.584	10.422	0.024	0.070	0.056
SPAIN	4,1	-0.072	0.953	0.174	0.937	4.932	0.055	0.041	0.027
GERMANY	2,0	-2.424	0.202	21.310	0.053	6.130	0.066	0.075	0.061
FRANCE	1,1	-3.439	0.187	32.229	0.119	9.333	0.016	0.077	0.063
ITALY	8,1	-0.194	0.874	1.235	0.386	5.931	0.079	0.025	0.010
UK	1,1	-3.929	0.101	20.205	0.087	11.058	0.011	0.079	0.065
US	6,7	-0.328	0.797	2.073	0.332	5.346	0.097	0.018	0.003
Panel B: SC Criterion and estimates of Equation (1)									
GERMANY	1,0	-1.817	0.370	15.849	0.234	6.847	0.039	0.062	0.048
ITALY	7,1	-0.187	0.878	1.174	0.404	6.350	0.068	0.025	0.010
US	2,1	-0.819	0.522	5.780	0.038	2.400	0.356	0.018	0.003
Panel C: HQ Criterion and estimates of Equation (1)									
GERMANY	1,0	-1.817	0.370	15.849	0.234	6.847	0.039	0.062	0.048
FRANCE	1,0	-3.786	0.303	35.524	0.257	9.609	0.013	0.077	0.063
ITALY	7,1	-0.187	0.878	1.174	0.404	6.350	0.068	0.025	0.010
US	6,3	-0.329	0.797	2.077	0.336	5.135	0.099	0.017	0.003