MA THESIS PAPER

UNIVERSITY OF CHICAGO

MAPSS-ECON PROGRAM, DIVISION OF SOCIAL SCIENCES

QUANTITATIVE ANALYSIS OF THE IMPACTS OF CARBON PRICING ON ENERGY INFLATION IN THE EUROPEAN UNION

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May 2023

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ACKNOWLEDGMENTS

The creation of this thesis would not be possible without the guidance and direction of Dr. Srinivasan Vasudevan, Asst. Instructional Professor of Economics at the University of Chicago, who served as the advisor for this project. His experience proved invaluable in transforming and progressing the work on this thesis.

ABSTRACT

The aim of this paper is to quantitatively analyze the relationships between carbon prices and energy inflation. We look at the history of carbon prices in the European Union Emissions Trading Scheme (EU ETS) and different measures of energy inflation throughout the history of the EU ETS in order to analyze the transformation of their relationship through time.

Our hypothesis is that the inflationary effects of carbon pricing have increased in magnitude and significance with time, with most of the pressure being put on the producers. We expect the relationship between carbon prices and producer prices to be direct.

First, we look at industrial and electricity prices collected semiannually and the corresponding carbon price data. After controlling for GDP and Gas Prices we find no statistically significant relationship between carbon prices and industrial electricity prices, but an inverse relationship between carbon prices and household electricity prices.

Then we looked at the bigger sample of energy inflation measures. Specifically, monthly collected Energy PPI and ICP (Producer Price Index and Index of Consumer Prices) were regressed on the carbon prices data. Now we conducted separate analyses for each of the four stages of the EU ETS's development. Results show a strongly significant inverse relationship between ICP and carbon prices in the earliest phase and a direct relationship between PPI and carbon prices in the latest phase of development.

These results support our hypothesis but bring more context to the discussion table. While the first step could not reveal any relationship between carbon prices and the producer prices as we predicted, this result is understandable after taking into account the next analysis which shows that only the latest period was significant. The inverse relationship between carbon prices is however a consistent result that is rather unintuitive. The explanation for it is likely in the fact that consumer electricity prices in the EU are under stricter regulations, and early after EU ETS's introduction the following policy changes could be associated with a negative movement in consumer electricity prices despite the carbon prices' growth.

CHAPTER 1

INTRODUCTION

Global warming is one of the main challenges for human beings in the 21st Century. The international community agreed to coordinate efforts on the mitigation of climate change under the United Nations Framework Convention on Climate Change (UNFCCC) and adopted specific commitments to reduce greenhouse gas (GHG) emissions under the Paris Climate Agreement in 2015. The Parties accepted different policies and measures aiming to decarbonize their economies. The European Union (EU) is among the world leaders, who adopted a target of reaching carbon neutrality by 2050.

The key policy tool that should help the EU to achieve this ambitious goal is the Emission trading system (EU ETS), which was launched in 2005. Nowadays it is the largest carbon market in the world, accounting for around 40 percent of the EU's GHG emissions. The market evolved in four phases, and the regulations have been updated continuously. Since 2005, carbon emissions in the EU got a pricing mechanism that, according to economic theory, must provide incentives for cost-effective emission control.

However, the strengthening of decarbonization policy and rising prices of carbon emission allowances in the EU leads to macroeconomic impacts, which remain poorly understood yet. One of the primary concerns for policymakers and the general public relates to rising inflation, which might be linked to substantially increasing carbon prices in recent months (to over 100 euros per ton of CO2). The high carbon price shocks should cause an immediate increase in energy prices and a slowing down of economic activity, which may be reflected in lower output and higher unemployment.

There is a sound theoretical basis for analysis of the role of pricing of environmental goods (e.g., emission allowances, pollution fees) based on the New Keynesian models. These topics have been considered in numerous scientific articles and reports. However, the recent studies of the EU ETS were mostly focused on the periods of relatively low carbon prices in the EU system, which existed in the first three phases of EU ETS from 2005 through 2020. The main specific feature of this study is that it reveals the impacts of the high carbon prices in the fourth phase of the EU ETS, which unprecedentedly raised from 31 euro/tCO2 in January 2021 to over 106 euro/tCO2 in early 2023. Such dramatic price rise becomes a strong factor for revision of the business models in the energy sector, technological innovation, the substitution of fossil fuels by green energy sources, as well as for the impacts on the economic situation and key macroeconomic indicators in the EU.

The aim of this research is to quantitatively estimate the magnitude and significance of the effects of carbon pricing on energy inflation for households and businesses. The relative importance of carbon pricing is also compared with the impacts of other determinants of energy pricing in the EU such as gas prices and GDP. To estimate the variation in response to price signals between time periods, the time control parameters are included in the analysis.

The hypothesis we propose is that Carbon Prices are a statistically significant driver of Energy Inflation, but the magnitude of the effect varies with time and between consumer and producer prices. Specifically, we expect the effect to grow in magnitude with time, as the coverage and influence of EU ETS grew, and the effect will likely be significantly lessened for consumers because of present high regulation. Consumers are more protected from inflation shocks than producers, so the effect is likely reduced in magnitude.

This study sheds some light on the inflationary consequences of climate policy and carbon pricing in the EU.

Of course, there are numerous factors affecting the energy prices in the EU, such as the prices of natural gas, oil, coal, electricity, and renewable energy costs. Also, the energy price shocks are often caused by unexpected events which are not anticipated by economic agents, while the carbon regulatory measures are pre-announced and well-known by them. The effects of climate policy depend on the design of the system, which may be revenue-neutral for the economy and not affect the financial burden of firms and households (some schemes provide compensation for energy bills' rise for households, thus reducing energy inflation for selected social groups). The central banks may also react to carbon price shocks to mitigate inflation. Analysis of all these aspects using more advanced economic modeling and analytical tools, which can be developed at further stages of my research, could reveal valuable insights into less known externalities of Carbon Emissions Regulation.

CHAPTER 2

REVIEW OF THE LITERATURE

There is a significant rise of interest in the assessment of the impacts of carbon pricing on various aspects of socioeconomic development and the environment in different countries in recent years with a special focus on the role of emission trading systems and carbon taxes. The efficiency of market-based approaches to air pollution abatement was first demonstrated in a series of micro-economic computer simulation studies in 1967 through 1970 for the National Air Pollution Control Administration (Burton and Sanjour, 1967; Burton and Sanjour, 1970). These studies found that the application of an emission trading scheme (so-called, «cap-and-trade») leads to a dramatically less costly reduction of air pollution than it is in any conventional abatement scheme.

The theoretical grounds for the analysis of the dynamic behavior of an economy under different environmental policy regimes were presented in a New Keynesian model embodying policies and measures on control of pollutant emissions and environmental policy. E.g., Annicchiarico, Di Dio (2015) developed a dynamic stochastic general equilibrium model of New Keynesian type and argued that an emissions cap policy is likely to dampen macroeconomic fluctuations and the optimal environmental policy response to shocks is strongly influenced by the degree to which prices adjust and by the monetary policy reaction.

The first and most successful implementation of the market-based regulatory scheme dealt with the US Acid Rain Program, which included a cap-and-trade system to provide market incentives for significant reduction of emission of hazardous pollutants (primarily, SO2 and NOx) in the energy sector. The program was launched in 1995, its environmental targets were fully reached in a relatively short time period, while the costs of its implementation were estimated to be about 5 times less than initially assessed by the US EPA (Chan et al, 2012).

The success of the Acid Rain Program led to introduction of the emission trading in the Kyoto Protocol of the UN Convention on Climate Change, the creation of the global market of carbon emission allowances and offset credits, the establishment of emission trading systems in the EU, China, several North-Eastern US states and California, New Zealand, many other countries and provinces.

The EU ETS emerged out of the failure of efforts throughout the 1990s to introduce a carbon tax in Europe, reasonable skepticism about the effectiveness of voluntary approaches, the Acid Rain program's achievements, and the incorporation of emission trading mechanisms in the Kyoto Protocol to UNFCCC. Alloisio and Galeotti (2022) provided a review of the actual experience of carbon pricing in European countries, analyzing the specifics of the implementation of a carbon tax and an emission trading system.

There are numerous studies aimed to assess the effectiveness of the EU ETS. Lian et al (2013) concluded that the over-allocation of emissions allowances in Phase 1 and the recession in Phase 2 have reduced the direct impact of the EU ETS on emissions, but the combination of rigorous monitoring and awareness, together with a positive carbon price, has driven some abatement. Bordignon and degl'Innocenti (2023) analyzed Phase 3 and revealed that the increase of purchased emission allowances (EUA) had a statistically significant, substantial impact on emissions reduction from Phase 2 to Phase 3.

Moessner (2022) found that increases in carbon prices on the EU ETS system have a significant effect on energy CPI inflation, but not on other types of inflation. This paper, however, did not consider the most outstanding year of 2022 when the major shifts in the EU energy sector and carbon market were observed. Nickel (2022) analyzed the impact of carbon pricing changes on inflation in several contexts. The author found that the effects are uncertain, but noted that there is a meaningful potential for the carbon market to have strong impacts on energy inflation and price volatility in the future.

Lilliestam, Patt, Bersalli (2021) concluded that the effectiveness of carbon pricing in stimulating innovation and zero-carbon investment remains a theoretical argument and there is no empirical evidence of its effectiveness in promoting the technological change required for full decarbonization. Haites et al (2023) identified the policy packages a country can implement to accelerate emission reduction by these sectors with minimal risk of leakage, including carbon pricing which is a critical component of each package due to its ability to minimize the risk of adverse economic impacts on domestic industry, support innovation and generate revenues to assist groups adversely affected due to carbon pricing and to build public support for the policies.

Metcalf and Stock (2020) analyzed the impact of carbon taxes in European countries over the past 30 years. They estimated the macroeconomic impacts of these taxes and concluded that there is a zero to a modest positive impact on GDP and total employment growth rates. Konradt and Weder di Mauro (2023) studied the effects of carbon pricing on inflation dynamics in Europe and Canada in the last three decades. Their empirical results suggest that carbon taxes did not significantly increase inflation, but affected relative price changes, increasing the cost of energy but leaving the price of other goods and services unaffected. The response to inflation was especially muted in countries with revenue-neutral carbon taxes and autonomous central banks that can accommodate potential inflationary pressure associated with carbon pricing.

The economic impacts of carbon pricing were also studied in China. The empirical analysis of carbon emission trading schemes in eight pilot regions in 2009-2015 showed a negative impact on employment and capital input but an improvement in the productivity of regulated firms (Cui et al, 2021). In that period, carbon emissions were reduced by 16.7%, but without a statistically significant effect on outputs and exports. Higher carbon prices and active allowance trading contributed to more pronounced effects of emission abatement in China. However, the carbon prices in Chinese regional ETSs have been relatively low (below 10-15 USD/tCO2), which might not provide sufficient signals to the economic actors, as it might have been in the case of higher prices like in the EU in the last few years.

Using the most recent data, theoretical foundations, and several econometric models, this work contributes to the understanding of the impacts of carbon pricing on energy inflation in the EU, significance of it in relation to other key economic factors, as well as the distributional consequences of carbon pricing (energy inflation impacts for households and businesses). A specific focus is made on the effects of boosting carbon prices in the fourth stage of EU ETS (since 2021).

CHAPTER 3

DATA FORMAT AND SOURCES

This study relies on several sources of data that was collected in different formats.

The main variable of interest is the Carbon Price. It is measured in Euros/tonne of CO2, and both semiannual and monthly observations are used.

The only other measures of Carbon Price are labeled CP1, CP2, CP3, and CP4 and simply represent the same measures of Carbon Price but controlled for specific periods of time. These periods correspond to specific stages in the EU ETS's development and cover the following time frames respectively: 2005-2007, 2008-2012, 2013-2020, and 2021-onwards.

As measures of energy inflation, four different variables were used:

1. Industrial Electricity Price (also known as the non-household electricity price) is measured in Euro/Kilowatt-hour and the data is available semiannually from 2007 to the first half of 2022.

2. Household Electricity Price is measured in Euro/Kilowatt-hour and the data is available semiannually from 2007 to the first half of 2022.

3. ICP is the variable for the Harmonized Index of Consumer Prices in the Energy sector in the EU. It is measured monthly and is centered at the value of 100 for the year 2015. Data from May 2005 to December 2022 is used.

4. PPI is the variable for the Producer Price Index in the Energy sector in the EU. It is measured monthly and is centered at the value of 100 for the year 2015. Data from May 2005 to December 2022 is used.

The Gas Price variable is the Global Price of Natural gas, measured in U.S. Dollars per Million Metric British Thermal Units. Monthly measurements from May 2005 to December 2022 are used.

The GDP variable is the Gross Domestic Product of the European Union (27 countries from 2020), measured in Millions of Euros. The data for GDP is typically collected quarterly, so the data is expanded to monthly by assuming the GDP was constant during each quarter. This assumption is likely to introduce some bias in the estimation, but it is unlikely to be significant since GDP doesn't vary much with time, and our main interest is in the other variable of Carbon Prices. In this work, the LogGDP variable is going to be used instead, which is calculated by $ln(GDP)$ and this change is meant to make the coefficient for the GDP make more sense after regression.

The Sources are respectively:

https://www.investing.com/commodities/carbon-emissions-historical-data

https://ec.europa.eu/eurostat/databrowser/view
/NRG_PC_205__custom_5222849/default/table?lang=en

https://ec.europa.eu/eurostat/databrowser/view
/NRG_PC_204__custom_5222893/default/table?lang=en

https://fred.stlouisfed.org/series/ENRGY0EUCCM086NEST

https://fred.stlouisfed.org/series/PIEAEN02EZM661N

https://fred.stlouisfed.org/series/PNGASEUUSDM

https://fred.stlouisfed.org/series/CPMNACSCAB1GQEU272020

CHAPTER 4

METHODOLOGY

The aim of this research is to estimate the magnitude and significance of the effects of carbon pricing on energy inflation. Additionally, the goal is to compare the relative importance of carbon pricing with other more prominent determinants of energy pricing like gas prices and GDP, as well as introduce time control variables that will allow identifying any developments in the relationship between energy inflation and Carbon Prices.

The study with a very similar topic of interest that I will be in part relying on estimated the effects of carbon pricing on inflation by dynamic panel regressions of New-Keynesian Phillip curves. The explanatory variables in this case very the different methods of carbon pricing quantified in several parameters. I will be deviating from this idea and trying to instead estimate the effects of carbon pricing specifically under the EU ETS and compare them to other important factors that determine energy inflation.

The challenges for analysis are related to the issue that energy price inflation is caused by a multitude of factors, and considering them all is practically impossible, but it is still feasible to estimate the significance of carbon pricing in changes in energy inflation if other most important factors are included which have the biggest explanatory power. The models proposed in this work are linear: it means that the results rely on the assumption that the relationship between the variables of interest is linear. This is a necessary assumption to make, but not an unreasonable one.

This analysis also relies on the assumption that simultaneity is not occurring. There are reasons why this can be considered a relatively valid assumption. The main reason is behind the process of determining carbon pricing: besides the market regulation that is happening and determining the price, ultimately the supply of allowances sold on the market is determined mostly by political events. The European Commission can actively legislatively change the goals and coverage of EU ETS (they proposed to legislatively change it in July 2021 in line with a more ambitious target of decarbonization), and since 2019 a Market Stability Reserve has been established to remove surplus allowances from the market. These active regulations are a large determinant of Carbon Prices but have no direct impact on electricity prices that are usually regulated to respond to more immediate challenges.

The specific models and variables used are specified in the next section together with the results.

CHAPTER 5

RESULTS AND DISCUSSION

Figure 1 illustrates the dynamics of prices of EU carbon allowances (EUA), natural gas, and electricity for households and industries in the EU during 2007-2022. The Y-axis is the price for a specific unit measured, with all the variables standardized to average 100. This will allow us to see the trends and fluctuations of all variables in the same space.

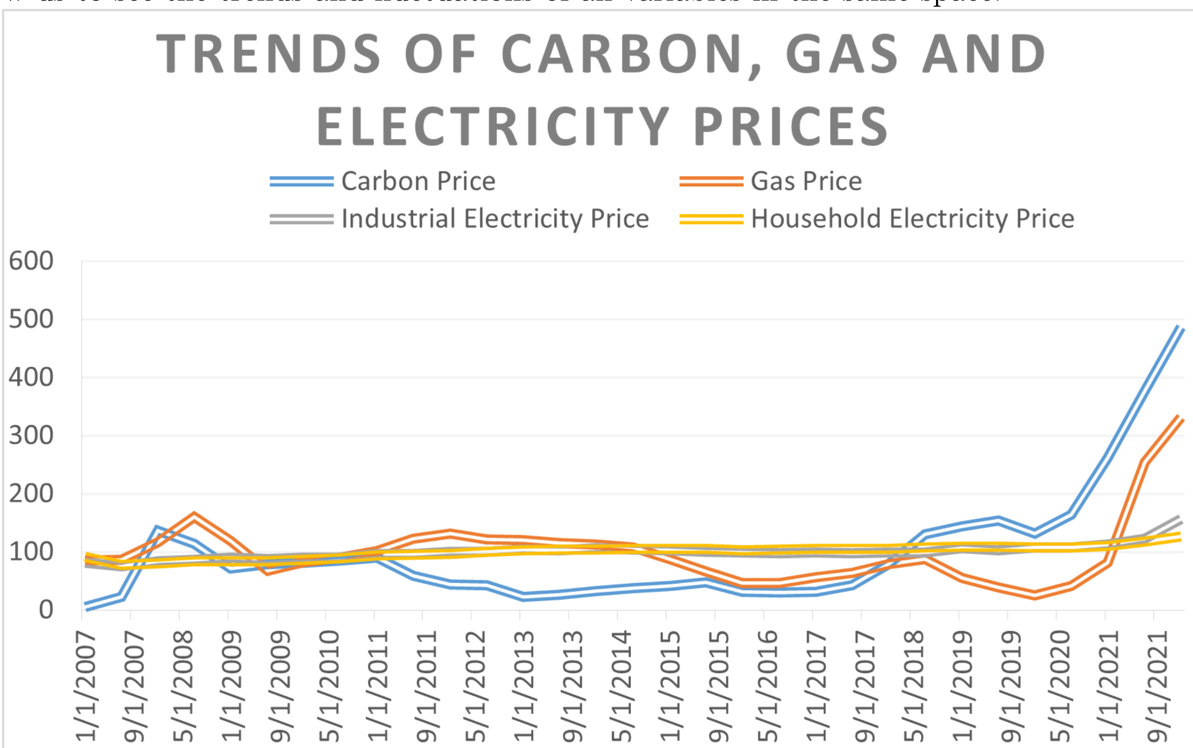

Figure 1: Dynamics of prices of carbon allowances, natural gas, and electricity for households and industries in the EU.

Evidently, Carbon Prices move very similarly to Gas Prices and have comparable volatility, but Electricity Prices measured semiannually appear to have very insignificant variation. Since not much is clear from the graph visually, let us perform a series of linear regressions to uncover the true relationships between variables.

Industrial Electricity Price (IEP) and Household Electricity Price (HEP) will be the dependent variables. For each, we first look at Carbon Pricing as the single explanatory variable and then add Gas Price and LogGDP variables as controls.

Our linear models will have the following form:

$IEP = \beta_0 + \beta_1 * CarbonPrice + U$ (1)

$IEP = \beta_0 + \beta_1 * CarbonPrice + \beta_2 * GasPrice + \beta_3 * LogGDP + U$ (2)

$HEP = \beta_0 + \beta_1 * CarbonPrice + U$ (3)

$HEP = \beta_0 + \beta_1 * CarbonPrice + \beta_2 * GasPrice + \beta_3 * LogGDP + U$ (4)

Table 1 demonstrates the respective outcomes of these simple Ordinary Least Squares Regressions that show the correlations and predictive potential of three explanatory variables and the two dependent variables.

Table 5.1: Output of linear regression for models 1, 2, 3, and 4

	Dependent variable:			
	‘Industrial Electricity Price‘		‘Household Electricity Price‘	
	(1)	(2)	(3)	(4)
‘Carbon Price‘	0.0008414***	−0.0000712	0.000671***	−0.0006426***
	(0.0001)	(0.0002)	(0.0002)	(0.0002)
‘Gas Price‘		0.001735***		0.0015164***
		(0.0005)		(0.0004)
LogGDP		0.133***		0.242***
		(0.026)		(0.024)
Constant	0.128***	−1.857***	0.188***	−3.417***
	(0.003)	(0.384)	(0.005)	(0.356)
Observations	31	31	31	31
R^2	0.586	0.797	0.301	0.859
Adjusted R^2	0.572	0.775	0.277	0.844
Residual Std. Error	0.01 (df = 29)	0.01 (df = 27)	0.02	0.01
F Statistic	41*** (df = 1; 29)	35*** (df = 3; 27)	12***	54***
Note:				*p<0.1; **p<0.05; ***p<0.01

Let’s look at the results for model 1 first. This result demonstrates that as a singular explanatory variable, Carbon Prices explain a very significant part of the variation in Industrial Electricity Prices: just over 58% according to the R- square value. It is statistically significant with a p-value close to 0, and the coefficient is positive. This confirms our intuition since we expect an increase in Carbon Prices to be related to an increase in the prices of electricity. There are, however, endogeneity concerns and omitted variable bias to be considered, and the results for model 2 consider the two main contributors to Electricity Prices to address these concerns.

The result for model 2 demonstrates that using three explanatory variables, Carbon Prices, Gas Prices, and GDP explains a larger part of the variation in Industrial Electricity Prices than just Carbon Prices: just under 80% according to the R-square value. However, the coefficient for Carbon Prices is not statistically significant anymore, unlike the coefficient for the newly introduced variables. The explanation for that is most likely in the amount of data: this result and the ones in the following sections of this paper suggest that Gas Prices and GDP are correlated with both the Carbon Price and the Energy Inflation measures used as the dependent variables, making the Carbon Price variable endogenous and biased. Introducing them into the regression removes this bias, but makes the effects of Carbon Prices harder to detect. Whatever the real effect of Carbon Prices is, it does not appear to be large in magnitude and thus requires more data points to identify. That is why a larger sample size and a more sensitive measure of Energy Inflation used in the following section provide more significant results.

Household Electricity Prices provide more interesting results when used as the dependent variable. Model 3 follows the same intuition as model 1 discussed above, and the results are comparable in magnitude and significance. Model 4, however, shows very different results for household consumers when the Gas Price and GDP are taken into account. The coefficient for Carbon Price is now negative while remaining statistically significant even at a 1% level.

These models demonstrate that the general intuition about the effects of carbon pricing and the concerns about it causing inflation may be misunderstood. There is no immediate evidence of increased Industrial Electricity Prices and in fact some evidence that for Household consumers the effects may be the opposite. However, the data on Electricity prices is scarce and is typically reported semi-annually, making the working sample quite small.

Let's take a more in-depth look at the problem using other measures of Energy inflation and a more complex model. In this next section, we will look at two different dependent variables:

1) The Producer Price Index for Economic Activities related specifically to the Energy sector in the Euro Area (PPI).

2) The Index of Consumer Prices for Economic Activities related specifically to the Energy sector in the European Union (ICP).

For both these indexes the base year is 2015 (with the corresponding value of 100) and the data is reported monthly, allowing for a deeper analysis from both the producer and the consumer sides.

As explanatory variables, we will use the Carbon Prices and the Gas Prices from the same datasets, but with the monthly data instead. In addition, a logarithmically transformed measure of GDP will also be used as an explanatory variable.

Figure 2 shows the trends over time for Carbon Prices, Gas Prices, PPI and ICP (all standardized to average 100):

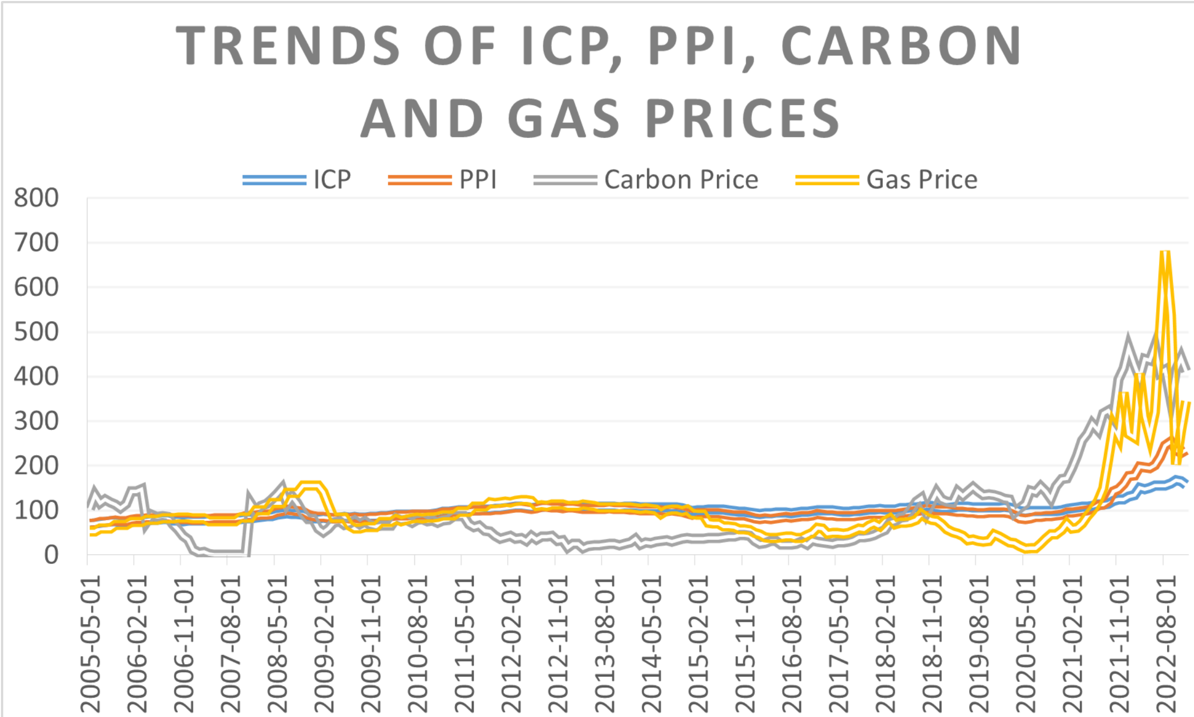

Figure 2: Dynamics of prices of carbon allowances, natural gas, the PPI, and the ICP in the EU.

Let's look at the results of analyzing the PPI first. The simplest model to test is as follows:

$PPI = \beta_0 + \beta_1 * CarbonPrice + U$ (5)

where Carbon Price is the only explanatory variable, β_0 is the intercept and β_1 is the coefficient of interest.

We will then introduce the Gas Price and GDP variables and see how the results change: The model will now be as follows:

$PPI = \beta_0 + \beta_1 * CarbonPrice + \beta_2 * GasPrice + \beta_3 * LogGDP + U$ (6)

One more important question to answer is whether there is a significant difference in the effects of carbon pricing depending on the EU ETS's stage of development. For this, we will introduce 4 new explanatory variables in place of Carbon Prices: CP1, CP2, CP3, and CP4 corresponding to Carbon Prices in different stages of EU ETS's growth. These stages cover the following periods respectively: 2005-2007, 2008-2012, 2013-2020, 2021-onwards.

Model (7) will look as follows:

$PPI = \beta_0 + \beta_1 * CP1 + \beta_2 * CP2 + \beta_3 * CP3 + \beta_4 * CP4 + \beta_5 * GasPrice + \beta_6 * LogGDP + U$

The outcome of linear regressions for these three models can be seen in Table 2.

Table 5.2: Output of linear regression for models 5, 6, and 7

	Dependent variable:		
	PPI		
	(5)	(6)	(7)
‘Carbon Price‘	1.319***	0.222***	
	(0.072)	(0.064)	
CP1			0.030
			(0.196)
CP2			0.073
			(0.147)
CP3			0.027
			(0.180)
CP4			0.289***
			(0.098)
‘Gas Price‘		2.723***	2.529***
		(0.126)	(0.151)
LogGDP		73.613***	69.543***
		(7.888)	(19.106)
Constant	84.532***	−1,020.640***	−956.388***
	(2.003)	(117.134)	(284.224)
Observations	212	212	212
R^2	0.614	0.889	0.892
Adjusted R^2	0.612	0.888	0.889
Residual Std. Error	21.023 (df = 210)	11.307 (df = 208)	11.231 (df = 205)
F Statistic	334*** (df = 1; 210)	557*** (df = 3; 208)	283*** (df = 6; 205)
Note:			*p<0.1; **p<0.05; ***p<0.01

Results for models (5) and (6) follow the intuition that higher Energy Inflation is correlated with higher Carbon Prices. Carbon Price is a statistically significant predictor of PPI that when used by itself has the ability to predict 61% of the variation in the PPI. This time, the coefficients are consistently positive and significant. However, the coefficient for Carbon Price changes in magnitude significantly after introducing Gas Prices and GDP into the calculation.

This implies that much of the effect that model (5) attributed to Carbon Prices was in fact coming from the fluctuations in Gas Prices and GDP which are also statistically significant explanatory variables. Their coefficients are also positive, which is to be expected. An increase in Gas Prices would surely affect energy prices through increased energy generation costs, and a GDP increase is connected to increased spending, and thus increased inflation and prices through growing borrowing.

The results for model (7) are very interesting and provide an intuition into the evolution of the EU ETS. The results for Gas Prices and GDP are similar to prior and follow the same intuition, remaining significant predictors of PPI in all models. The results for Carbon Prices in different periods are much more thought-provoking. The p-values that represent statistical significance are generally decreasing from CP1 to CP4, and only CP4 is a statistically significant predictor. For CP1, CP2, and CP3 the significance is so low that it's impossible to determine if the relationship is direct or inverse, let alone get an understanding of the specific coefficient magnitudes. For the last stage of EU ETS's development, however, the effect is pronounced and statistically significant. This result supports our hypothesis that Carbon Prices became a more significant determinant of Energy and Electricity prices as the trading scheme developed and increased in volume and influence. The lower Carbon Prices in the earlier periods could not create a significant enough effect to be meaningful in the context with other explanatory variables like the Gas prices and the GDP, but gained influence on producers as the prices and volumes increased.

Let's now repeat the process for the second dependent variable, the ICP, which will reveal the other side of the problem.

The simplest model to test is

$ICP = \beta_0 + \beta_1 * CarbonPrice + U$ (8)

The next model we introduce is

$ICP = \beta_0 + \beta_1 * CarbonPrice + \beta_2 * GasPrice + \beta_3 * LogGDP + U$ (9)

And analogously to the analysis for the PPI, the last model (10) is

$ICP = \beta_0 + \beta_1 * CP1 + \beta_2 * CP2 + \beta_3 * CP3 + \beta_4 * CP4 + \beta_5 * GasPrice + \beta_6 * LogGDP + U$

The regression output for these three models can be seen on the next page.

Similar to the results discussed before, the outcome for model (8) is intuitive and follows the same pattern. This model, however, is biased, as we have established before, so let's see how improving the model will change the results.

The result for model (9) completely contradicts the established intuition and the previous result. The coefficients for Gas Price and GDP are as expected, and are statistically significant and positive similar to the PPI analysis. The Carbon Price coefficient, however, has changed its sign while remaining significant, albeit less than in the previous model.

The implication is that the direct effects of Gas Prices and GDP that were previously attributed to Carbon Prices are so significant that they managed to change the sign of the Carbon Price coefficient. This new perspective shows that when taking the other variables into account, on the consumer side of the problem Carbon Prices have an inverse relationship with Energy prices, opposite to how it is for producers. This outcome does, however, match our previous finding when analyzing Household Electricity Prices. We find again that the relationship between Carbon Prices and Energy Inflation for consumers is inverse.

The outcome for model (10) elaborates on the previous results and again shows that there is a meaningful difference between the effects of Carbon Prices in different stages of EU ETS's development. Unlike the result for PPI, the p-value that represents the statistical

Table 5.3: Output of linear regression for models 8, 9, and 10

	Dependent variable:		
	ICP		
	(8)	(9)	(10)
‘Carbon Price‘	0.583***	−0.103**	
	(0.045)	(0.041)	
CP1			−0.363***
			(0.124)
CP2			−0.158*
			(0.093)
CP3			−0.105
			(0.114)
CP4			−0.009
			(0.062)
‘Gas Price‘		1.016***	0.888***
		(0.080)	(0.096)
LogGDP		95.585***	81.159***
		(5.005)	(12.082)
Constant	89.159***	−1,334.246***	−1,117.675***
	(1.239)	(74.330)	(179.732)
Observations	212	212	212
R^2	0.448	0.834	0.839
Adjusted R^2	0.445	0.831	0.835
Residual Std. Error	13.006 (df = 210)	7.175 (df = 208)	7.102 (df = 205)
F Statistic	170*** (df = 1; 210)	347*** (df = 3; 208)	178*** (df = 6; 205)
Note:			*p<0.1; **p<0.05; ***p<0.01

significance of the Carbon Prices coefficient appears to be increasing with time, with the results for CP1 being the only statistically significant ones at a 95% confidence level. CP2 coefficient is still significant under 90% confidence level and suggests these results are at least of some importance. This implies that in the first two stages of development from 2005 to 2012 Carbon Price increases actually related to a decrease in the inflation levels in the Energy sector on the consumer side. This opposes what we have observed before in the case of producers.

Konradt and Weder di Mauro (2023) come to similar conclusions in their report about carbon taxes. They looked at carbon tax policies instead of cap-and-trade schemes but also found significant deflationary effects for consumers. One of the theories they propose is that carbon taxes may reduce household income and expenditures, thus depressing prices. This would align well with our observation that the first periods were the most statistically significant since most carbon tax policies that would produce this effect would be introduced in these earlier stages.

CHAPTER 6

CONCLUSIONS

The application of different regression models allowed us to identify the impacts of carbon prices on energy inflation in the EU for producers and consumers. The simple models confirmed that an increase in carbon prices is related to an increase in the prices of electricity. However, there is no immediate evidence of the impact of carbon price rise on the increase in industrial electricity prices. The analysis allowed us to identify which periods of the EU ETS development were corresponding to the most significant statistical effect, and to what scale they were different for producers and consumers. The lower carbon prices in the earlier stages of the EU ETS could not create a sufficient effect to be meaningful compared with other explanatory variables like gas prices and GDP but gained influence on producers as the prices and volumes increased. But at the last stage of EU ETS with high carbon prices, the effect is well pronounced and statistically significant. The regression analysis supports our hypothesis that carbon prices became a more significant determinant of energy and electricity prices as the emission trading scheme developed and increased in volume and influence. It was revealed that the mechanisms responsible for translating a change in carbon prices on the EU ETS market have evolved in such a manner that its effect on consumers diminished and its effect on producers increased. The observed trend suggests that carbon prices can with time become an even more significant driver of energy inflation, at least on the producers' side, so taking this potential development into account could prove useful in constructing further policy on carbon pricing aimed at reducing carbon emissions in the European Union.

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