HOW CARBON TAXES AND OIL PRICES SHAPE INFLATION?

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Abstract: ***The global economy is developing at a rapid pace, but this progress is accompanied by severe environmental consequences, especially in the context of the COVID-19 pandemic's long-term impact and the economic instability caused by conflicts and political fluctuations. We believe that carbon taxes are a macro factor contributing to changes in the inflation rate. Therefore, this paper aims to analyze the impact of carbon taxes on inflation and their level of influence on the relationship between oil prices and inflation. Our findings show that carbon taxes can alleviate inflationary pressure caused by an increase in oil prices. Our research offers valuable insights for policymakers to adopt a dual approach to protecting the environment while stabilizing inflation.***

• Keywords: *carbon taxes, climate change, inflation, oil prices.*

JEL codes: G10; G18; E31; H23

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1. Introduction

Oil and other fuels are currently a choice of vital resources for the global economy since it is appropriate in nearly all economic areas. They are used for economic and social activities such as production, transportation, ect. And these activities cause carbon emissions, which are one of the elements that cause climate change. Any changes in oil prices can impact both microeconomic choices and macroeconomic policies (Gokmenoglu et al., 2015). Moreover, oil prices also have a prime impact on the fall and rise of inflation in any country throughout the world. Bermingham (2008) investigated Ireland's meager free economy and discovered the influence of rising oil prices on inflation. Jacquinot et al. (2009) investigated a similar problem for the Eurozone and discovered that oil price fluctuations have a significant impact in short-term inflation forecasting, even supposing the impact is much more complicated as an eventual outcome. Previous studies have shown that carbon taxes accomplish their purpose of lowering emissions, such as studies by Murray and Rivers (2015) for Canada; Best et al. (2020) for Europe. Moessner (2022) investigated the impact of carbon dioxide emissions on inflation and showed that higher carbon dioxide emissions can be associated with higher inflation at the national level.

Our study examines the relationship between carbon taxes, oil prices, and the inflation rate. We analyze how carbon taxes and oil prices affect inflation in 22 countries, both developed and developing, across various continents, including Europe, Asia, America, and Africa. The analysis uses annual data from the largest currently available dataset of countries implementing carbon taxes per ton of CO2 emissions into the environment. The research relies on secondary data collected from Datastream and other reliable sources, with an unbalanced dataset displayed from 1991 through 2021. Many countries have implemented carbon taxes to combat climate change by taxing carbon emissions from energy sources like oil. While some countries, like Chile, maintain stable carbon tax rates for several years, most countries in our research sample adjust the carbon tax annually to effectively reduce emissions and support the goal of achieving net-zero emissions. Revenue from carbon taxes is often reinvested in climate-related initiatives, such as developing low-carbon technologies or transitioning to low-carbon energy sources. We are curious if increasing taxes on carbon emissions can address both rising emissions and the stabilization of inflation, particularly in the context of inflation driven by rising oil prices.

The study is organized as follows. Section 2 reviews the literature and lays out our main hypotheses. Section 3 details the data and models. We report the results in Section 4, robustness checks in Section 5, and concluding remarks in Section 6.

2. Literature review

One technique for reducing greenhouse gas emissions is carbon pricing. Governments do not use repressive measures but instead provide a market-based mechanism for regulating emissions. This leaves manufacturers with a choice between reducing emissions to avoid paying high prices or continuing to emit but paying a fee for their emissions. Two main carbon pricing mechanisms are Emission Trading Systems (ETS) and Carbon Taxes (CTs). However, in this research, we focus on carbon taxes. One key distinction between ETS and CTs is that the emission reduction outcomes of carbon taxes are not predetermined, whereas emissions credits trading in ETS

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is based on predetermined allowances. Finland pioneered the creation of a worldwide carbon tax to replace service and income taxes in 1990. Norway followed suit in 1991, covering 65 percent of all CO2 emissions. Sweden also began imposing carbon taxes in 1991, resulting in a 13 percent decrease in the country's CO2 emissions between 1987 and 1994. In the United Kingdom (UK), an additional 15 percent tax was imposed in 2001 in response to climate change, affecting taxation standards in both the public and commercial sectors that are based on energy prices.

According to Kaenzig (2021), ETS carbon price surprises in Europe, carbon pricing, and related carbon policies have a positive impact on emission reductions, assisting in meeting emission reduction targets and slowing down the transition to climate change, but doing so must come at a cost, which is related to energy prices and consumption. McKibbin et al. (2021) found that a carbon price only has a temporary effect on inflation when using simulation models. Nevertheless, according to Andersson et al. (2020), the benefits of continuous innovation in renewables in response to carbon pricing, reduced power prices, and increased energy efficiency might offset these larger inflationary pressures, potentially leading to a decline in the share of energy within the CPI consumption basket. According to Konradt and Di Mauro (2023), carbon taxes did not significantly boost inflation; the dynamic impacts were estimated to be near zero in most scenarios. Instead, they found evidence of relative price increases, which raised the cost of energy while leaving other goods and services unchanged. In summary, the existing analyses of how carbon prices affect the economy remain inconclusive and contentious. Our study contributes to this topic by examining the influence of carbon prices on inflation and the variables that influence inflation, with the expectation that carbon taxes would have a positive effect on stabilizing inflation. Therefore, our first hypothesis is as follows:

H1. The carbon taxes help reduce the inflation rate

Many studies have suggested that there is a pass-through between oil prices and headline inflation, although the effect is weak, cyclical, and diminishes over time. According to research by Blanchard and Galí (2007), inflation and economic activity were significantly more affected by oil price shocks. They attribute this to the weakening of wage rigidities, the increasing credibility of monetary policy, and a decrease in the proportion of oil in consumption and output.

H2. Oil prices directly make the inflation rate increase

Moessner (2022) investigated the impact of carbon dioxide emissions on inflation and found that implementing climate change policies does not necessarily lead to higher inflation. Instead, higher carbon dioxide emissions can be associated with higher inflation at the country level. Konradt and Di Mauro (2023) demonstrated that any inflationary effects of carbon taxes are limited to headline inflation and do not extend to core inflation. While they observed modestly deflationary responses in Canadian provinces, the findings in Europe suggest moderate and imprecisely measured effects. To the best knowledge of the authors, there is currently no clear evidence regarding the association between oil prices and the inflation rate in the presence of the carbon tax factor. As a result, the authors conducted this research to examine the influence of carbon taxes on inflation, as well as the link between inflation and oil prices, providing useful reference data for policymakers in their efforts to stabilize inflation. Our last hypothesis is presented:

H3. The carbon taxes mitigate the adverse effects of the rise in oil prices on inflation

3. Data and models

3.1. Data

The research dataset comprises 327 observations and is presented in the form of a table, collected from 1991 to 2021, with a sample size of 22 countries worldwide (see Appendix A). This timeframe was chosen because it is long enough to capture market fluctuations influenced by significant global events, such as the Iraq war and the SARS pandemic (2003), the 2007-2008 World Economic Crisis, the public debt crisis in Europe (2010), Brexit (2020), and the US-China trade war (2019), along with the ongoing COVID-19 pandemic. The primary explanatory variable in the models is carbon tax data, collected from the comprehensive World Bank dataset.

3.2. Models

In this paper, we examine (1) the influence of macro factors, including oil prices and carbon taxes on inflation, and (2) the direction and impact level of the global oil price on inflation when countries levy carbon taxes. First, we use a basic dynamic model to examine the influence of macro factors, including oil prices and carbon taxes, on inflation.

$$INF_{i,t} = \beta_0 + \beta_1 INF_{i,t-1} + \beta_2 CT_{i,t-1} + \beta_3 OIL_{t-1} + \varphi V_{i,t} + \delta_t + \alpha_i + \mu_{i,t} \quad (1$$

$$INF_{i,t} = \beta_0 + \beta_1 INF_{i,t-1} + \beta_2 CT_{i,t-1} + \beta_3 OIL_{t-1} + \beta_4 OIL_{t-1} \times CT_{i,t-1} + \varphi V_{i,t} + \delta_t + \alpha_i + \mu_{i,t} \quad (2$$

Where i refers to firm and t refers to periods; δ_t is the error term in correlation to time-specific effects; α_i is the error term associated with firm-specific effects which include unobservable firm-specific characteristics, and $\mu_{i,t}$ is the random error term. The dependent variable INF is the annualized percentage change in a consumer price index extracted from the Datastream for country i at time t. The key independent variables are proxied to observe macroeconomic factors' effects such as carbon taxes, global oil prices on inflation. V denotes a vector of firm-level control variables as recommended by the prior research (Andersson et al.,2020; Kaenzig, 2021;

Moessner, 2022; Di Mauro, 2023). A detailed list of variables, definitions, and sources can be found in Table 1.

Table 1. Variable definitions

Variables	Definitions	Sources
Dependent variable		
INF	Change in consumer price index (CPI) over the previous year	Datastream
Main explanatory variables		
OIL	Change in global oil price over the previous year	Macrotrends and Authors' calculation
CT	Change in the price of carbon tax over the previous year	World Bank and Authors' calculation
Interactive variable		
OIL×CT	Interactive between change in global oil price and change in carbon tax	Authors' calculation
Control variables		
OUTPUT	The distinction between actual and prospective output (the yield gap percentage)	Datastream
M2	M2 money supply growth over the previous year	Datastream
REER	Change in the real effective exchange rate index over the previous year	World Bank and Authors' calculation
TRADE	Trade surplus and trade deficit (dummy variable)	Datastream
PPI	Change in the producer price index from the previous year	Datastream

We employ a panel data estimation approach that incorporates multi-way fixed effects (FE), including time and country fixed effects. To address potential issues of endogeneity and unobservable heterogeneity associated with fixed firm effects within the dynamic model, we also apply the System-GMM (S-GMM) approach as a robustness check for our results.

Table 2. Descriptive statistics

Variables	N	Mean	Std. Dev.	Min	Max
INF	296	0.0232	0.0229	-0.0063	0.1391
OIL	295	0.0728	0.1924	-0.2880	0.7495
CT	308	0.0264	0.2964	-0.6496	0.5412
OUTPUT	295	-0.0172	0.0278	-0.0924	0.0370
M2	296	0.0763	0.0543	-0.0368	0.2873
REER	296	-0.0003	0.0380	-0.1053	0.1014
TRADE	308	0.6169	0.4869	0.0000	1.0000
PPI	295	0.0268	0.0473	-0.0803	0.2282

Table 2 presents a summary of statistics for our sample. The average value of INF is 0.0232 with standard deviation of 0.0229. The maximum and minimum values of INF are 0.1391 and -0.0063, respectively. The OIL variable's respective figures for mean and standard deviation calculated from 295 observations are 0.0728 and 0.1924. The smallest value of OIL is -0.288 and the largest one is 0.7495. Similarly, CT has the mean value of 0.0264 and standard deviation of 0.2964. With 308 observations in total, the lowest and highest value of CT are -0.6496 and 0.5412 accrordingly. The explanation is similar for other variables. The heterogeneity in the number of observations is due to winsorizing to remove outliers.

We utilize Pearson and Spearman correlation tests to examine the relationships among the variables. The correlation coefficients show modest absolute values, all below 0.6. Furthermore, the Variance Inflation Factors (VIF) scores fall within the range of 1.06 to 1.58, with a mean of 1.24, indicating that multicollinearity concerns are absent in our study. Please note that the correlation table is not included in this report, but the authors can furnish it upon request.

4. Main results

The results from Table 3 indicate that inflation has been influenced by changes in carbon taxes and the price of oil. To be specific, higher changes in carbon taxes lead to a decrease in the inflation level. This is evident from the negative and significant regression coefficient of CT at the 1% and 10% significance levels when using the S-GMM method. In model (1), an increase of 1 percentage point in carbon taxes corresponds to a 0.0136 percentage point decrease in the inflation rate, and this direction aligns with that observed in model (2).

Table 3. Carbon taxes, oil prices, and inflation

Variables	FE		S-GMM	
Model	(1) INF_t	(2) INF_t	(1) INF_t	(2) INF_t
$INF_{i,t-1}$	0.395*** (3.94)	0.394*** (4.26)	0.4732*** (2.85)	0.7673** (2.45)
$CT_{i,t-1}$	-0.0051 (-1.18)	-0.0084* (-1.91)	-0.0136*** (-2.91)	-0.0200* (-1.66)
OIL_{t-1}	0.0077*** (3.47)	0.0075*** (2.74)	0.0181*** (6.29)	0.0235*** (4.15)
OIL_{t-1} × $CT_{i,t-1}$	-	-0.0394** (-2.51)	-	-0.0521** (-2.55)
$OUTPUT_{i,t-1}$	-0.0595 (-1.25)	-0.0501 (-1.06)	-0.3600*** (-4.56)	-0.5206*** (-4.40)
$M2_{i,t-1}$	0.117*** (4.98)	0.112*** (4.82)	0.1087*** (7.23)	0.0952*** (3.19)
$REER_{i,t-1}$	-0.0574** (-2.26)	-0.0561** (-2.25)	-0.0593*** (-3.75)	-0.0777* (-1.87)
$TRADE_{i,t-1}$	0.0006 (0.18)	0.0003 (0.09)	-0.0029 (-0.21)	-0.0004 (-0.01)
$PPI_{i,t-1}$	-0.0078 (-0.28)	0.0017 (0.05)	-0.0061 (-0.32)	-0.0532 (-1.20)
Constant	0.0026 (0.74)	0.0038 (1.11)	0.0003 (-0.02)	0.0070 (-0.27)
Year fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Obs	226	226	226	226
N.countries	22	22	22	22
R2	0.354	0.376	-	-
F-test	8.75***	8.76***	4,977.2***	331.07***
Hansen test (p_value)	-	-	0.574	0.463
AR2 (p-value)	-	-	0.761	0.571

*Notes: *,**,and *** are statistically significant at the 10%, 5% and 1% levels, respectively. T-statistics are given in parenthesis*

After regressing model (1) and examining the effect of CT and OIL on INF, we introduced the interactive variable OIL×CT in model (2) to explore the relationship among carbon taxes, oil prices, and inflation. In model (2), the variable CT shows that a 1 percentage point increase in carbon taxes corresponds to a 0.02 percentage point decrease in inflation. In contrast, the variable OIL, representing global oil prices, produces positive results. In model (1), a 1 percentage point increase in the price of oil leads to a 0.0181 percentage point increase in inflation, which is consistent with both academic research and practical expectations. Higher oil prices tend to raise logistics costs, resulting in increased prices for goods and services. The interactive variable OIL×CT in model (2) negatively affects INFt at the 5% level of statistical significance. With a regression coefficient of -0.0521 for OIL×CT, we can conclude that short-term bullishness in oil prices drives the inflation rate upward. However, in the context of carbon tax implementation, the positive effect of higher oil prices on the inflation rate is mitigated. Our results from S-GMM align with those of Konradt and Di Mauro (2023) in the case of Canadian provinces. However, we strongly support the idea that levying a carbon tax will reduce inflation with a 1-year lag. Additionally, we find that carbon taxes effectively mitigate the adverse impact of oil price increases on the inflation rate. As a result, our hypotheses 1, 2, and 3 are confirmed and accepted. Apart from OIL, CT, and the interactive variable OIL×CT, control variables such as OUTPUT, M2, REER are all statistically significant at the 1% level.

5. Robustness check

By substituting carbon taxes changes (CT) with the natural logarithm of carbon emissions trading credit prices (CETS), we conduct a robustness check to assess the impact of both CETS and OILxCETS on inflation. As a result, we formulate our models (3) and (4) as follows:

$$INF_{i,t} = \beta_0 + \beta_1 INF_{i,t-1} + \beta_2 CETS_{i,t-1} + \beta_3 OIL_{t-1} + \varphi V_{i,t} + \delta_t + \alpha_i + \mu_{i,t} \quad (3$$

$$INF_{i,t} = \beta_0 + \beta_1 INF_{i,t-1} + \beta_2 CETS_{i,t-1} + \beta_3 OIL_{t-1} + \beta_4 OIL_{t-1} \times CETS_{i,t-1} + \varphi V_{i,t} + \delta_t + \alpha_i + \mu_{i,t} \quad (4$$

CETS stands for Carbon Emission Trading Scheme adoption on the country-level, aimed at reducing carbon emissions. We perform this robustness check to determine whether carbon pricing, as measured by another scheme other than carbon taxes, has the same effect on inflation as carbon taxes or not. The list of countries using the Carbon Emission Trading Scheme as a form of carbon pricing will be displayed in Appendix B.

Table 4. Robustness check: alternative proxy for carbon taxes

Variables	FE		S-GMM	
Model	(3) INF_t	(4) INF_t	(3) INF_t	(4) INF_t
$INF_{i,t-1}$	0.206** (2.55)	0.176** (2.31)	0.6537*** (3.11)	1.0991*** (3.60)
$CETS_{i,t-1}$	-0.0017 (-1.72)	-0.0010 (-1.23)	-0.0055*** (-5.78)	-0.0039* (-1.66)
OIL_{t-1}	0.0005 (0.16)	0.0376*** (4.41)	0.0189*** (2.90)	0.1094** (2.37)
$OIL_{t-1} \times CETS_{i,t-1}$		-0.0153*** (-4.04)		-0.0355* (-1.80)
$OUTPUT_{i,t-1}$	-0.0388 (-0.92)	-0.0298 (-0.70)	-0.1333*** (-3.75)	-0.1309*** (-2.62)
$M2_{i,t-1}$	0.0625** (2.75)	0.0593** (2.65)	0.0830*** (3.22)	0.0753** (2.01)
$REER_{i,t-1}$	0.0097 (0.29)	0.0086 (0.28)	-0.0558* (-1.74)	-0.1093** (2.23)
$TRADE_{i,t-1}$	-0.0016 (-0.44)	-0.0024 (-0.69)	-0.0066 (-0.40)	0.0140 (0.43)
$PPI_{i,t-1}$	0.0903** (2.45)	0.109*** (2.97)	-0.1259 (-1.39)	-0.2182 (-1.58)
Constant	0.0126*** (3.29)	0.0126*** (3.60)	0.0186 (1.43)	-0.0029 (-0.12)
Year fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Obs	231	231	231	231
N. countries	20	20	20	20
R2	0.174	0.214	-	-
F-test	5.53***	8.76***	561.09***	761.83***
Hansen test (p_value)	-	-	0.604	0.403
AR2 (p-value)	-	-	0.713	0.782

*Notes: *,**,and *** are statistically significant at the 10%, 5% and 1% levels, respectively. T-statistics are given in parenthesis.*

The results from Table 4 show that CETS in model (3) and (4) has a negative sign with INF, which has the same effect on inflation as CT in model (1) and (2). Once again, this implies that applying carbon pricing helps mitigate not only the amount of carbon emissions but also the acceleration of the inflation rate with a lag of one year. In the case of the interactive variable OIL×CETS in model (4), this also yields a similar finding as OIL×CT in model (2). In the condition of applying carbon taxes or participating in trading carbon emission credit, the impact of the volatility of oil prices on the inflation rate would be eased.

6. Concluding remarks

Our study outcomes match up with our given expectations. The results indicate that the global oil price and carbon taxes significantly impact inflation in both developing and advanced countries. The model of lag variables shows that levying carbon taxes mitigates the acceleration of inflation caused by the higher oil price. Moessner (2022) also studied that higher carbon emissions were associated with higher inflation and nations with better climate policy rankings tend to be associated with lower inflation across countries. Based on these results, we can explained that carbon taxes help reduce carbon emissions, and therefore help mitigate the adverse effect of higher inflation. This is an optimistic and meaningful result. There are some reasonable explanations for the deflation effects of implementing carbon taxes. Firstly, levying carbon taxes can depress household income and force them to cut back consumption, which leads to a downward trend in price. Secondly, levying carbon taxes intensifies investing and producing less energy-intensive goods and services and gradually does not use much energy for producing, which may cause less use of nonrenewable energy sources. Based on this outcome, the enforcement of a carbon tax to accelerate the movement to zero carbon is not constrained by considering the inflationary impact. This implication is significant since carbon pricing regimes have been demonstrated to reduce carbon emissions.

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