Can monetary and fiscal policy reduce CO2 emissions? Analysis of regional country groups

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Abstract

There are calls for monetary and fiscal authorities to use policy tools to support ongoing efforts to achieve the net zero emissions goal. However, limited attention has been paid to the regional differences in the relationship between monetary-fiscal policy and CO2 emissions. This study examines the impact of monetary and fiscal policy on carbon dioxide (CO2) emissions from fossil fuel energy consumption. The study extends the literature by linking monetary and fiscal policy to climate action for achieving the net zero emissions goal. In the empirical analysis, the monetary policy indicator is the lending interest rate, the fiscal policy indicator is the tax revenue to GDP ratio while CO2 emissions from fossil fuel energy consumption is the CO2 emissions indicator. The findings reveal that contractionary monetary and fiscal policy jointly reduce CO2 emissions in the regions of the Americas and Africa. Contractionary monetary and fiscal policy combined with higher renewable energy consumption jointly reduce CO2 emissions in the regions of the Americas, Asia and Europe. Also, contractionary monetary and fiscal policy combined with higher institutional quality jointly reduce CO2 emissions in African countries. Higher renewable energy consumption reduces CO2 emissions in Africa, Asia, Europe and Americas regions while strong institutional quality consistently reduce CO2 emissions in Europe and the Americas. The implication of the findings is that monetary and fiscal authorities should strengthen existing institutions, increase renewable energy consumption, and increase interest rate and taxes on the fossil fuel economy in a coordinated manner to reduce CO2 emissions from fossil fuel energy consumption.

Keywords: CO2 emissions, monetary policy, fiscal policy, institutional policy, population, interest rate, tax revenue to GDP ratio, net zero, sustainable development, renewable energy, economic growth, Africa, Asia, Europe, Americas.

JEL code: G01, G21, G28, M4, Q02, Q28, Q25.

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1. Introduction

This article examines the impact of monetary and fiscal policy on carbon dioxide (CO2) emissions from fossil fuel energy consumption. Specifically, it examines whether interest rate and taxes can reduce CO2 emissions in countries. The study contributes to on-going policy and academic discussions on the need to achieve the net zero emissions goal of cutting greenhouse gas emissions to as close to zero as possible. Recently, there has been increasing advocacy for collective effort from the private sector, the public sector, and international development agencies to contribute to achieving the net zero emissions goal (Sun et al, 2021; Deutch, 2020). This has intensified the need to provide a policy environment that enables individuals, firms and governments to reduce their carbon footprint towards reducing CO2 emissions (Sasse et al, 2020; Bataille, 2020).

Interestingly, monetary and fiscal authorities of countries have been singled out as powerful agents who can use monetary and fiscal policy tools to slow down the pace of economic activity which will decrease economic growth and ultimately reduce CO2 emissions because fewer production of goods and services leads to fewer CO2 emissions (McConnell et al, 2022; Dikau et al, 2021; Semmler et al, 2021). The increased focus on the policy tools of the monetary and fiscal authorities is also due to their ability to influence the terms and flow of credit in the economy as well as their ability to influence spending behaviour (Bartocci et al, 2022). Given their important role in the economy, there are calls for the monetary and fiscal authorities to use specific policy tools to support ongoing efforts to achieve the net zero emissions goal.

This study makes a strong case for the use of contractionary monetary and fiscal policy tools to achieve the net zero emissions goal. Contractionary monetary and fiscal policy can slow down economic activity, reduce the production of goods and services, and reduce CO2 emissions which supports the attainment of the net zero emissions goal. However, contractionary monetary and fiscal policy comes with huge economic costs, such as loss of jobs and low income, etc, which are detrimental to societal wellbeing. Notwithstanding, these effects can be mitigated by using differentiated monetary policy to influence the flow of money and credit to industries whose activities do not emit CO2 into the environment and by using differentiated fiscal policy to influence the spending behaviour of individuals and businesses in ways that lower CO2 emissions. Given the important role of monetary and fiscal policy in achieving the net zero emissions goal, there is a need to examine the role of monetary and fiscal policy in supporting the realization of the net zero emissions goal among regional country groups.

In the literature, scholars continue to search for a wide range of determinants or factors that accelerate the attainment of the net zero emissions goal (see. Meadowcroft and Rosenbloom, 2023; Han et al, 2024). However, limited attention has been paid to specific monetary and fiscal policy tools as potential determinants of the realization of the net zero emissions goal. Little attention has also been paid to the regional differences in the impact of monetary and fiscal policy on the net zero emissions goal. The few studies in the literature that examine this topic did not provide a comparative regional assessment of the impact of monetary and fiscal policy on CO2 emissions. For instance, Benkhodja et al (2022) examine the effect of green fiscal policy and unconventional green monetary policy on the economy but they did not compare their findings across regions or country groups. In a related study, Bartocci et al

(2022) used carbon taxes and purchase of long-term sovereign bonds as potential fiscal policy and monetary policy tools for combating CO2 emissions. Still, their findings cannot be generalized to regions outside the Euro Area. Meanwhile, Bildirici et al (2023) examined the case of Turkey while Pradeep (2021) focused on India and the two-studies document mixed evidence which makes it difficult to draw any meaningful regional inference. Although a few studies such as Li et al (2023), Bildirici et al (2023) and Pradeep (2021) examined the role of fiscal and monetary policy in achieving the net zero emissions goal, these studies did not examine regional country groups. As a result, no regional inference can be drawn from their studies. The general lack of comparative regional analysis on the impact of monetary and fiscal policy on CO2 emissions in the literature makes it difficult to determine whether monetary-fiscal policy has a stronger effect on CO2 emissions in Asia, Europe, Africa or the Americas. This study aims to fill this gap in the literature by investigating the impact of monetary and fiscal policy on CO2 emissions.

The novel contribution of this study is the analysis of regional country groups. Undertaking a comparative regional analysis of the impact of monetary and fiscal policy on CO2 emissions from fossil fuel energy consumption will reveal any regional differences in the monetary-fiscal policy transmission mechanism and its effect on CO2 emissions from fossil fuel energy consumption. This study also control for important factors, such as population size, level of employment in industry, institutional quality, economic growth and renewable energy consumption, which were not considered as control variables in previous studies that investigate the impact of monetary and fiscal policy on CO2 emissions from fossil fuel energy consumption. This study also contributes to the finance and sustainable development literature that examine the role of government policy in stimulating financing (via credit and taxes) for sustainable development activities (e.g., Benkhodja et al, 2022; Bartocci et al, 2022; Bildirici et al, 2023; Pradeep, 2021; Canofari et al, 2023) but which have not examined in great depth, the role of monetary and fiscal policy for achieving the net zero emissions goal. The study contributes to this literature by extending the analysis to a diverse set of country groups to gain insights that can inform policymaking towards realizing the net zero emissions goals.

The central argument in this article is that contractionary monetary and fiscal policy can slow down economic activity and lower CO2 emissions, and this effect will differ across regional country groups due to regional differences in monetary-fiscal policy transmission mechanisms. This is the fundamental premise in this study. In the empirical analyses, sixty-three countries are analysed using the lending rate as the monetary policy indicator, the tax revenue to GDP ratio as the fiscal policy indicator and fossil fuel energy consumption as the measure of CO2 emissions which controlling for other important factors. The findings show that contractionary monetary and fiscal policy reduce CO2 emissions from fossil fuel energy consumption in the regions of the Americas and Africa. Contractionary monetary and fiscal policy combined with higher renewable energy consumption jointly reduce CO2 emissions from fossil fuel energy consumption in the regions of the Americas, Asia and Europe. Also, contractionary monetary and fiscal policy combined with higher institutional quality jointly reduce CO2 emissions from fossil fuel energy consumption in African countries. Higher renewable energy consumption reduces CO2 emissions in the Africa, Asia, Europe and Americas regions while strong institutional quality consistently reduce CO2 emissions in Europe and the Americas.

The remainder of the study is structured as follows. Section 2 presents the related literature.

Section 3 presents the hypothesis. Section 4 presents the research design of the study while the estimation results are discussed in Section 5. The conclusion of the study is presented in section 6.

2. Related Literature

Existing studies advocate for government policy intervention to achieve the net zero emissions goal. Bataille (2020) suggests the rapid formation of policy-led regional and sectoral transition plans by countries to reduce CO2 emissions. They suggest increasing the quantity and quality of recycling through deliberate regulation, the removal of fossil energy subsidies, the introduction of carbon pricing, and government support for research and development into decarbonized production technologies, among others. Gudde et al (2021) examine the case of the United Kingdom (UK) and examine the policy stance of the local authorities in the UK regarding achieving the net zero emissions goal. They discovered that, since 2018, more than 70 percent of the UK local authorities have committed to achieving net zero greenhouse gas emissions. The local authorities also embraced the concept of citizens' climate assemblies as a way of engaging civil society. The authors conclude that without commitment on the part of the local authorities, achieving net zero emissions goal will be difficult. Millot et al (2020) examine the pathways adopted by France and Sweden towards net zero transition. They note that after the oil crisis of the 1970s, the two countries decided to reduce their oil consumption by developing nuclear power. Sweden adopted a well-diversified energy policy which allowed it to reduce its CO2 emissions, but France did not adopt a well-diversified energy policy. They compare the two countries' progress in achieving net zero and find that over the years France has faced more challenges in transforming its energy system than Sweden.

Few recent studies in the literature examine the role of monetary and fiscal policy on CO2 emissions. Benkhodja et al (2022) examine the effect of green fiscal policy and unconventional green monetary policy on the economy. They find that fiscal policy instruments such as carbon tax and subsidy for the purchase of green goods are beneficial to the green sector while green quantitative easing is not beneficial to the economy. Their findings suggest that green fiscal policy is more effective than green monetary policy for low-carbon transition of the economy. In a related study, Bartocci et al (2022) examine the effect of fiscal policy, such as increasing carbon taxes, on the use of fossil fuel in the Euro Area and the interaction effect with domestic monetary policy. They find that increasing carbon tax has recessionary consequences, and that monetary policy can mitigate this effect through the purchase of long-term sovereign bonds in the secondary market which will reduce long-term interest rate. Another study focus on the type of central bank monetary policy mandate. D'Orazio and Popoyan (2023) examine whether the type of monetary policy mandate of central banks influence the adoption of climate-related financial policies in G20 countries. They find that the monetary policy mandate of central banks have a significant effect on the adoption of climate-related financial policies in G20 countries country. They also find that the independence of the central bank and being a member of the Sustainable Banking Network positively influence the adoption of climate-related financial policies in G20 countries. Wu et al (2023) also examine the role of monetary policy in reducing CO2 emissions across countries from 2000 to 2019. They use money supply as the indicator of monetary policy and find that there is a nonlinear and positive association between money supply and CO2 emissions and

the effect of monetary policy on CO2 emissions is weaker for countries with high level of human development and moderate manufacturing share of GDP.

The literature also document mixed evidence on the impact of monetary and fiscal policy on CO2 emissions. For example, Li et al (2023) examine the effect of fiscal policy and environmental stringent policy on consumption-based CO2 emissions from 1990 to 2019. They find that fiscal policy, in terms of government expenditure, increases CO2 emissions while fiscal policy, in terms of taxation revenue and environmental policy stringency, mitigate CO2 emissions. In contrast, Bashir et al (2024) find that fiscal policies, such as government expenditures and taxation, hinders a smooth energy transition. Bildirici et al (2023) examine the case of Turkey and assess the effect of monetary and fiscal policy on CO2 emissions from 1978 to 2021 and find that contractionary monetary and fiscal policy decrease CO2 emissions in Turkey. In contrast, Pradeep (2021) focus on monetary policy, and examines the impact of monetary policy on CO2 emissions in India over an extended period from 1971 to 2014. The author used the autoregressive distributed lag methodology and find that contractionary monetary policy, such as high interest rates, increase CO2 emissions in India both in the short and long run.

The above empirical studies in the literature did not provide a regional comparative assessment of the impact of monetary and fiscal policy on CO2 emissions, neither did they examine the impact of interest rate and taxes on CO2 emissions from fossil fuel energy consumption on a regional basis. The lack of comparative regional analysis in the existing literature makes it difficult to determine whether monetary and fiscal policy have a stronger effect on CO2 emissions in Asia, Europe, Africa or the Americas. This study fills this gap in the literature by investigating the impact of monetary and fiscal policy on CO2 emissions among regional country groups.

3. Hypothesis

The dependent variable in the model is the fossil fuel energy consumption indicator (CO2) which is commonly used to measure CO2 emissions from fossil fuel energy consumption in the literature (see, for example, Ayompe et al, 2021; Destek and Pata, 2023). The focal independent variables are the lending interest rate variable (MP) and the tax revenue to GDP ratio (FP). The MP variable represents the interest rate or lending rate in the economy, which is largely influenced by central bank monetary policy actions. A high lending rate can signal a contractionary monetary policy stance of the monetary authority. A high lending rate will reduce the flow of credit to the economy, slow down economic activity and decrease CO2 emissions due to the general reduction in the level of economic activity. This implies that higher lending rates can decrease CO2 emissions. The FP variable is the indicator of fiscal policy which is the tax revenue to GDP ratio, and it is widely used in literature as a measure fiscal policy (Ozili, 2024). High taxes reduce the level of spending in the economy, decrease the level of economic activity and decrease CO2 emissions due to the general reduction in the level of economic activity (Akbar et al, 2022). This implies that taxes can decrease CO2 emissions. The institutional quality index (ISI) is a control variable constructed from the principal component analysis of the corruption control index, political stability index, government effectiveness index, regulatory quality index, rule of law index and the voice and

accountability index. The literature shows that strong institutions can mitigate the negative environmental externalities arising from economic activity (Stef et al, 2023; Boateng et al, 2024). Strong institutions can introduce and enforce regulations that reduce the emission of CO2 into the environment (Boateng et al, 2024). Following this argument, the institutional quality index (ISI) should have a negative relationship with CO2 emissions. The population variable (POP) was introduced into the model to control for higher CO2 emissions in the economy arising from a large population. The larger the population, the greater the use of fossil fuel energy sources, which will lead to higher CO2 emissions.

The renewable energy consumption variable (REN) controls for the provision of low-cost alternative clean (renewable) energy sources to replace fossil fuel energy consumption with renewable energy consumption. Greater renewable energy consumption should lead to a decrease in fossil fuel energy consumption (Zeppini and Van Den Bergh, 2020). The real interest rate variable (RIR) tracks the inflation rate. A negative real interest rate indicates a loss in the purchasing power of money due to high inflation. Loss in purchasing power will decrease the level of spending, lead to a decline in economic activity and decrease CO2 emissions. The GDP growth variable (GDPR) represents the level of economic growth. Positive economic growth indicates a higher level of economic output which will lead to higher CO2 emissions in the economy because more output are produced using fossil fuel energy sources since the transition to renewable energy sources is slow in many countries (Salari et al, 2021). The EP variable captures the level of employment in industry. As more people are employed to produce goods or provide services in the mining, quarrying, manufacturing, construction, and public utilities (electricity, gas, and water) industries, more fossil fuel energy will likely be used in these industries, thereby leading to higher CO2 emissions.

4. Research design

4.1. Sample data and period

Sixty-three (63) countries were analysed in the study: fifteen from African countries, twenty-one from European countries, sixteen from Asian countries and eleven countries from the region of the Americas consisting of North America and South America. The countries included in the sample were selected based on data availability. They had substantial data observations for at least four consecutive years of data reporting. Countries with too few annual data observations were excluded from the sample. The data is annual in its trend, and the sample period is from 2009 to 2023. This sample period was selected to exclude the 2007-2008 global financial crisis and to capture the post-crisis developments arising from the global net-zero emissions agenda. CO2 emissions data, economic and institutional data were collected from the world development indicators (WDI) of the world bank (see table 1). During the data cleaning process, some of the selected countries had missing year observations, thereby making the sample an unbalanced panel sample.

Table 1. Variables description and sources			
Variable	Indicator Name	Definition	Source
CO2	Fossil fuel energy consumption (% of total)	CO2 emissions from fossil fuel energy consumption from coal, oil, petroleum, and natural gas products.	World development indicators (WDI)
MP	Lending interest rate (%)	Lending rate is the bank rate that usually meets the short- and medium-term financing needs of the private sector. This rate is highly influenced by central bank monetary policy decisions.	WDI
FP	Tax revenue (% of GDP)	Tax revenue refers to the compulsory transfers to the central government for public purposes.	WDI
GDPR	GDP growth (annual %)	Annual percentage growth rate of GDP at market prices based on constant local currency.	WDI
ISI	Institutional quality	Principal component analysis of the corruption control index, political stability index, government effectiveness index, regulatory quality index, rule of law index and accountability index.	WDI
POP	Population, total	Natural log of total population size	WDI
RIR	Real interest rate (%)	Real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator.	WDI
REN	Renewable energy consumption (% of total final energy consumption)	Renewable energy consumption is the share of renewable energy in total final energy consumption.	WDI
EP	Employment in industry (% of total employment)	Persons of working age who were engaged in any activity to produce goods or provide services for pay or profit in the industry such as mining and quarrying, manufacturing, construction, and public utilities (electricity, gas, and water)	WDI

Source: World Bank's world development indicators (WDI)

4.2. Modeling and estimation procedure

The econometric model adopted in this study is similar to the model used in Ozili and Iorember (2024).

$$CO2i,t = \beta 0 + \beta 1MPi,t + \beta 2FPi,t + \beta 3GDPRi,t + \beta 4ISIi,t + \beta 5POPi,t + \beta 6RIRi,t + \beta 7RENi,t + \beta 8EPi,t + ei,t \ldots\ldots\ldots Eq\ (1)$$

Where CO2 = CO2 emissions from fossil fuel energy consumption (%). MP = the interest rate or lending rate (%). FP3 = tax revenue to GDP ratio (%). ISI = institutional quality index. REN = renewable energy consumption (%). RIR = real interest rate (%). GDPR = GDP growth (annual %). POP = natural logarithm of total population size. EP = employment in industry (% of total employment). i = represent country. t = year. εit is the error term. **The main estimation method is the panel fixed effect estimation with year fixed effect and with country-clustered standard errors. The fixed effect estimation controls for year-invariant factors and it controls for omitted variables.**

4.3. Descriptive statistics and correlation matrix

The descriptive statistics in table 2 show that taxes are about 15.6% of GDP on average in the full sample. A higher tax revenue to GDP ratio is reported in Sweden (27.1%) and Namibia (30.3%) compared to Kuwait (0.9%). The interest rate or lending rate is, on average, 10.9% but is reportedly higher in Brazil (39.1%) compared to the United Kingdom (0.5%). Renewable energy consumption is quite significant in the Democratic Republic of Congo (95.9%) compared to Kuwait (0.02%). CO2 emissions is also high in some countries such as Azerbaijan (97.9%) compared to the Democratic Republic of Congo (3.6%). Similarly, institutional quality is much stronger in Singapore and the United States than in the Democratic Republic of Congo. The remaining variables exhibit similar variation across countries. Meanwhile, the Pearson correlation matrix in table 3 reports that higher interest rate (MP3) is significantly correlated with fewer CO2 emissions while higher taxes (FP) are significantly correlated with higher CO2 emissions. Also, strong economic growth, high real interest rate and higher renewable energy consumption are correlated with fewer CO2 emissions. In contrast, strong institutional quality, high population growth and greater employment in industry are correlated with higher CO2 emissions.

Table 2. Full sample and country descriptive statistics

S/N	Country	Region/Group	CO2	MP	FP	REN	RIR	GDPR	EP	POP	ISI
1	Congo, Dem. Rep.	Africa	3.6	30.1	8.1	95.9	15.2	6.03	9.1	18.2	-3.8
2	Republic of Congo	Africa	40.4	-	8.6	65.3	-	1.5	23.6	15.4	-2.3
3	Cote d'Ivoire	Africa	24.1	5.1	10.9	67.6	3.1	5.7	11.3	17.0	-0.8
4	South Africa	Africa	87.1	9.4	23.5	8.5	3.7	1.1	20.2	17.8	1.9
5	Ethiopia	Africa	5.2	-	7.5	91.7	-	8.6	7.4	18.4	-1.4
6	Ghana	Africa	50.5	-	12.3	45.5	-	5.6	16.9	17.1	1.6
7	Kenya	Africa	18.3	14.6	14.6	71.2	6.5	4.7	14.1	17.6	-0.4
8	Nigeria	Africa	18.2	15.8	-	82.3	6.6	3.4	12.4	19.1	-2.1
9	Tanzania	Africa	12.7	16.1	11.1	83.8	8.4	5.6	6.8	17.8	-0.1
10	Zambia	Africa	9.0	13.8	14.8	85.4	4.1	4.8	10.1	16.6	0.1
11	Togo	Africa	19.7	5.1	12.6	75.02	3.7	5.2	18.9	15.8	-1.2
12	Namibia	Africa	66.6	9.2	30.3	30.7	3.5	2.4	15.5	14.6	2.6
13	Angola	Africa	45.2	18.0	13.0	51.1	3.9	1.5	7.3	17.1	-1.8
14	Botswana	Africa	66.5	8.3	24.0	27.2	2.2	2.9	17.1	14.6	3.6
15	Mauritius	Africa	82.7	8.4	17.7	10.6	5.5	3.0	25.6	14.0	4.2
16	Albania	Europe	60.6	8.3	17.9	39.1	5.9	2.8	19.4	14.8	-2.1
17	Croatia	Europe	73.2	9.8	20.9	31.2	8.4	1.2	27.6	15.2	-0.7
18	Czechia	Europe	78.1	4.4	14.3	14.1	1.7	1.3	37.7	16.1	0.7
19	France	Europe	48.5	-	14.9	13.6	-	0.8	20.7	18.0	1.1
20	Finland	Europe	44.6	-	20.2	41.2	-	0.3	22.3	15.5	2.9
21	Georgia	Europe	70.0	13.2	22.3	29.3	7.9	4.8	12.1	15.1	-1.2
22	Germany	Europe	80.0	-	11.3	14.5	-	0.9	27.7	18.2	2.0
23	Italy	Europe	82.0	3.7	24.5	15.7	2.1	0.1	27.0	17.9	-0.4
24	Norway	Europe	59.7	3.4	24.7	57.8	0.4	1.2	19.7	15.4	2.8
25	United Kingdom	Europe	84.6	0.5	25.3	7.5	-1.2	1.1	18.6	17.9	1.7
26	Ukraine	Europe	78.6	18.0	18.2	5.1	1.1	-2.5	25.3	17.5	-3.7
27	Sweden	Europe	30.9	-	27.1	50.3	-	1.8	18.7	16.1	2.6
28	Switzerland	Europe	51.0	2.6	9.4	23.3	2.5	1.5	21.0	15.9	2.8
29	Romania	Europe	75.2	8.9	16.03	23.2	3.6	2.2	29.7	16.7	-1.3
30	Netherland	Europe	92.2	1.7	22.0	6.5	0.9	1.1	16.3	16.6	2.5
31	Belarus	Europe	91.5	12.9	13.9	7.3	-4.4	1.3	31.5	16.1	-4.2

32	Bosnia & Herzegovina	Europe	90.0	5.3	19.6	24.8	2.8	1.9	31.2	15.1	-2.9
33	Bulgaria	Europe	72.4	7.03	19.7	17.1	2.5	1.7	30.8	15.8	-1.4
34	Hungary	Europe	71.5	5.8	22.4	14.8	0.6	1.8	31.0	16.1	-0.3
35	Iceland	Europe	10.9	8.5	23.1	79.1	3.6	2.1	18.1	12.7	2.1
36	Moldova	Europe	89.9	12.2	16.9	21.7	3.7	2.5	11.2	14.8	-2.8
37	China	Asia	88.1	4.9	9.2	12.9	2.4	7.0	30.2	21.1	-1.1
38	India	Asia	72.1	9.7	10.7	34.5	3.9	6.1	24.4	21.0	-0.6
39	Indonesia	Asia	65.7	11.2	10.3	27.7	5.8	4.7	21.1	19.3	-0.7
40	Japan	Asia	89.7	1.3	11.0	6.2	1.4	0.5	24.9	18.6	4.1
41	Korea Republic	Asia	82.5	4.2	14.8	2.4	2.5	2.7	24.7	17.7	2.6
42	Malaysia	Asia	96.7	4.6	13.3	4.1	2.8	4.1	27.6	17.2	1.2
43	Pakistan	Asia	60.2	11.3	-	45.2	3.0	3.5	23.5	19.1	-2.9
44	Philippines	Asia	59.9	6.3	13.1	30.6	3.9	4.9	17.1	18.4	-0.9
45	Singapore	Asia	95.7	5.3	13.1	0.6	3.6	4.0	17.5	15.5	5.1
46	Thailand	Asia	80.1	4.3	15.1	22.6	2.4	2.3	22.0	18.1	-0.7
47	Sri Lanka	Asia	46.5	10.9	10.2	52.3	3.9	3.1	26.4	16.8	-0.7
48	Azerbaijan	Asia	97.9	17.4	13.6	2.3	12.5	2.3	14.2	16.1	-2.1
49	Bangladesh	Asia	71.8	10.7	7.9	32.9	3.3	6.2	20.1	18.8	-2.5
50	Jordan	Asia	97.3	8.4	15.3	5.3	5.2	2.4	20.8	16.0	-0.06
51	Kuwait	Asia	95.7	4.6	0.9	0.02	5.1	0.7	24.8	15.1	-0.01
52	Mongolia	Asia	93.4	18.5	15.3	3.1	8.5	5.7	19.4	14.9	-0.4
53	Argentina	Americas	88.9	35.1	9.3	9.4	-5.5	0.8	21.2	17.5	-1.5
54	Brazil	Americas	55.5	39.1	13.9	45.6	29.8	1.4	22.0	19.1	-1.2
55	Chile	Americas	73.4	6.8	17.8	26.4	2.7	2.6	23.1	16.7	2.9
56	Costa Rica	Americas	48.4	12.4	13.2	36.5	8.1	3.3	18.3	15.4	1.6
57	Dominican Republic	Americas	85.8	13.6	13.1	16.1	8.2	4.6	18.8	16.1	-1.5
58	Jamaica	Americas	81.7	15.4	25.1	10.4	7.5	0.3	15.9	14.8	-0.2
59	Mexico	Americas	90.5	6.2	11.6	10.0	1.3	1.4	23.9	18.6	-2.1
60	Paraguay	Americas	33.0	19.2	9.5	61.7	14.9	3.3	18.9	15.6	-2.6
61	Peru	Americas	74.6	16.1	15.0	29.4	12.1	3.3	16.9	17.2	-1.6
62	USA	Americas	83.4	3.6	10.2	9.2	1.8	1.9	19.4	19.5	3.6
63	Uruguay	Americas	54.1	12.3	18.2	55.6	3.9	2.4	19.9	15.0	2.7
	Total statistics:	Mean	64.5	10.9	15.6	32.1	4.8	2.8	20.5	16.8	-0.34
		Median	72.4	9.1	14.5	25.3	4.07	3.03	20.3	16.7	-0.4
		Maximum	99.9	95.8	37.6	97.0	47.9	17.2	38.5	21.1	5.2
		Minimum	2.7	0.5	0.7	0.00	-33.5	-28.7	5.6	12.6	-5.1
		Std. Dev.	26.4	8.7	5.8	26.2	7.8	4.1	6.5	1.6	2.2
		Observations	393	756	815	819	756	945	881	945	945

Source: Author's own work

Table 3. Pearson correlation matrix

Variables	CO2	MP	FP	GDPR	ISI	POP	RIR	REN	EP
CO2	1.000								

MP	-0.308***	1.000							
	(0.00)	-----							
FP	0.125**	-0.091	1.000						
	(0.02)	(0.11)	-----						
GDPR	-0.179***	0.093*	-0.243***	1.000					
	(0.00)	(0.09)	(0.00)	-----					
ISI	0.094*	-0.451***	0.234***	-0.069	1.000				
	(0.09)	(0.00)	(0.00)	(0.22)	-----				
POP	0.130**	-0.050	-0.420***	0.133**	-0.149***	1.000			
	(0.02)	(0.37)	(0.00)	(0.01)	(0.00)	-----			
RIR	-0.212***	0.515***	-0.051	-0.016	-0.168***	-0.065	1.000		
	(0.00)	(0.00)	(0.37)	(0.77)	(0.00)	(0.24)	-----		
REN	-0.953***	0.359***	-0.132**	0.254***	-0.178***	-0.090	0.233***	1.000	
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.11)	(0.00)	-----	
EP	0.481***	-0.327***	0.035	-0.282***	0.065	0.080	-0.218***	-0.528***	1.000
	(0.00)	(0.00)	(0.52)	(0.00)	(0.24)	(0.15)	(0.00)	(0.00)	-----

*,**,*** refers to the 10%, 5% and 1% significance levels while the probability values are reported in parenthesis

Source: Author's own work

5. Empirical result

5.1. Baseline estimation result

The baseline empirical result reported in table 4 shows that the MP coefficient is negatively significant in the region of the Americas, indicating that higher lending rate significantly reduces CO2 emissions from fossil fuel energy consumption in the region of the Americas. The result is consistent with the findings of Bildirici et al (2023) who show that contractionary monetary policy mitigates CO2 emissions. Also, FP coefficient is positively significant in the region of the Americas, indicating that higher taxes significantly increase CO2 emissions from fossil fuel energy consumption in the region of the Americas. The result is inconsistent with the findings of Li et al (2023) and Bildirici et al (2023) who show that fiscal policy in terms of taxation revenue mitigates CO2 emissions. The policy implication of this result is that interest rate can mitigate CO2 emissions than tax revenue in the region of the Americas.

On the other hand, some of the control variables report the expected signs. The ISI and REN coefficients are negatively significant in the full sample, Europe and Americas country group, indicating that strong institutional quality and renewable energy consumption decrease CO2 emissions from fossil fuel energy consumption in the region of the Americas and Europe. This

result supports the findings of Zeppini and Van Den Bergh (2020) who show a link between renewable energy consumption and fossil fuel energy consumption. The result is also consistent with the findings of Boateng et al (2024) who show that institutional quality can mitigate CO2 emissions. The GDPR and EP coefficients are positively significant in the Americas country group, indicating that positive economic growth and industry employment lead to higher CO2 emissions in the region of the Americas. This result is consistent with the argument made by Salari et al (2021) on the positive relationship between economic growth and CO2 emissions. Meanwhile, the RIR and POP coefficients are statistically insignificant.

Table 4. Impact of monetary policy and fiscal policy on CO2 emissions

Panel fixed effect regression (including year fixed effect with country-clustered standard errors)

Variable	Full sample	North & South America	Europe	Africa	Asia
C	82.598***	25.877	114.89**	92.929***	83.711***
	(0.00)	(0.43)	(0.04)	(0.00)	(0.00)
MP	0.003	-0.291**	-0.701	0.047	0.292
	(0.98)	(0.03)	(0.20)	(0.47)	(0.47)
FP	0.228	1.111*	0.824	-0.039	0.066
	(0.31)	(0.05)	(0.18)	(0.79)	(0.78)
GDPR	0.506**	0.878**	0.247	0.020	-0.049
	(0.01)	(0.01)	(0.48)	(0.88)	(0.76)
ISI	-0.832*	-1.702**	-3.389**	0.704	-0.590
	(0.10)	(0.01)	(0.02)	(0.14)	(0.41)
POP	0.607	2.486	-1.691	0.429	0.245
	(0.29)	(0.16)	(0.59)	(0.43)	(0.65)
RIR	-0.009	-0.159	0.004	0.006	0.028
	(0.87)	(0.44)	(0.98)	(0.88)	(0.52)
REN	-0.991***	-0.811***	-0.949***	-0.998***	-0.885***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
EP	-0.058	0.618*	-0.249	-0.298*	0.279
	(0.70)	(0.09)	(0.41)	(0.08)	(0.46)
R^2	92.27	95.98	84.50	99.26	91.09
Adj R^2	91.91	94.90	81.98	99.04	89.38
F-statistic	255.87	88.73	33.49	463.34	53.28
P(F-statistic)	0.00	0.00	0.00	0.000	0.000

p-values are in parenthesis. ***,**,* represent statistical significance at the 1%, 5%, 10% levels.

Source: Author's own work

5.2. Interaction analysis: Joint effect of monetary and fiscal policy on CO2 emissions

This section assesses the combined effect of monetary and fiscal policy on CO2 emissions across the country groups and the full sample. Conducting the interaction analysis is important to take into account the role of monetary and fiscal policy coordination in mitigating CO2 emissions from fossil fuel energy consumption.

In table 5, the MP*FP coefficient is negatively significant in the Americas and Africa country groups. This indicates that higher interest rate and higher tax revenue jointly reduce CO2 emissions from fossil fuel energy consumption in the region of the Americas and Africa. The result is consistent with the findings of Li et al (2023) and Bildirici et al (2023) who show that

contractionary monetary and fiscal policy mitigate CO2 emissions. However, the MP*FP coefficient is insignificant in the Asia and Europe country groups, indicating that interest rate and tax revenue do not have a joint significant effect on CO2 emissions from fossil fuel energy consumption in the Asian and European countries in the sample. The policy implication of this result is that monetary and fiscal policy coordination can reduce CO2 emissions from fossil fuel energy consumption in the regions of the Americas and Africa. The monetary and fiscal authorities in the Americas and African regions should therefore increase interest rate and taxes on the fossil fuel economy in a coordinated manner to reduce CO2 emissions.

On the other hand, some of the control variables report the expected signs. The ISI and REN coefficients are also negatively significant in the Europe and Americas country group, indicating that strong institutional quality and renewable energy consumption decrease CO2 emissions from fossil fuel energy consumption. This result also supports the findings of Zeppini and Van Den Bergh (2020) who show an association between renewable energy consumption and fossil fuel energy consumption. The result is also consistent with the findings of Boateng et al (2024) who show that institutional quality reduces CO2 emissions. The GDPR coefficient is positively significant in the Americas country group, indicating that positive economic growth leads to higher CO2 emissions in the region of the Americas. This result is also consistent with the argument made by Salari et al (2021) on the relationship between economic growth and CO2 emissions. Meanwhile, the RIR coefficient is statistically insignificant.

Table 5. Interaction analysis: Joint impact of monetary policy and fiscal policy on CO2 emissions

Panel fixed effect regression (including year fixed effect with country-clustered standard errors)

Variable	Full sample	North & South America	Europe	Africa	Asia
C	82.827***	6.675	110.28**	99.507***	79.401***
	(0.00)	(0.82)	(0.04)	(0.00)	(0.00)
MP*FP	-0.007	-0.064*	-0.130	-0.052**	-0.093
	(0.73)	(0.10)	(0.14)	(0.04)	(0.13)
MP	0.095	0.511	1.608	0.499**	1.540
	(0.71)	(0.26)	(0.31)	(0.01)	(0.13)
FP	0.288	2.149**	1.516*	0.372***	0.696*
	(0.37)	(0.01)	(0.05)	(0.00)	(0.09)
GDPR	0.502**	0.721**	0.391	-0.083	-0.009
	(0.01)	(0.02)	(0.31)	(0.46)	(0.94)
ISI	-0.837*	-1.720**	-3.185**	0.791**	-0.569
	(0.10)	(0.01)	(0.01)	(0.04)	(0.36)
POP	0.565	3.132*	-2.254	0.218	0.031
	(0.33)	(0.06)	(0.44)	(0.64)	(0.96)
RIR	-0.008	-0.114	0.182	-0.009	-0.012
	(0.89)	(0.62)	(0.24)	(0.89)	(0.85)
REN	-0.994***	-0.841***	-0.938***	-1.031***	-0.931***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
EP	-0.065	0.438	-0.237	-0.518***	0.297
	(0.68)	(0.19)	(0.38)	(0.00)	(0.36)
R^2	92.28	96.36	85.60	99.34	91.78
Adj R^2	91.89	95.29	83.06	99.09	90.06

F-statistic	238.39	89.94	33.69	409.79	53.58
P(F-statistic)	0.000	0.000	0.000	0.000	0.000
p-values are in parenthesis. ***,**,* represent statistical significance at the 1%, 5%, 10% levels.					

Source: Author's own work

5.3. Moderating role of renewable energy consumption

The literature argue that greater renewable energy consumption can lead to a reduction in fossil fuel energy consumption in countries (Dong et al, 2020). The argument is that greater access to low-cost renewable energy sources will increase renewable energy consumption and reduce fossil fuel energy consumption in countries (Kuldasheva and Salahodjaev, 2023; Dong et al, 2020). Therefore, it is important to assess whether greater renewable energy consumption can moderate the relationship between monetary-fiscal policy and CO2 emissions.

The moderation analysis reported in table 6 shows that the MP*REN and FP*REN coefficients are positively significant which suggests that high interest rate and higher renewable energy consumption, or higher taxes and higher renewable energy consumption, do not constrain CO2 emissions from fossil fuel energy consumption, rather it increases it. However, the MP*FP*REN coefficient show evidence that higher taxes and interest rate combined with higher renewable energy consumption jointly reduce CO2 emissions from fossil fuel energy consumption in the region of the Americas, Asia and Europe. This result supports the findings of Kuldasheva and Salahodjaev (2023) and Dong et al (2020) who show that renewable energy consumption mitigates CO2 emissions.

Interestingly, the control variables report the expected signs. The ISI and REN coefficients are negatively significant in the Europe and Americas country group, indicating that strong institutional quality and renewable energy consumption decrease CO2 emissions from fossil fuel energy consumption. This result also supports the findings of Zeppini and Van Den Bergh (2020), who show a correlation between renewable energy consumption and fossil fuel energy consumption. The result is also consistent with the findings of Boateng et al (2024) who show that institutional quality can mitigate CO2 emissions. The GDPR coefficient is positively significant in the Americas country group, indicating that positive economic growth leads to higher CO2 emissions in the region of the Americas. This result is also consistent with the argument made by Salari et al (2021) on the relationship between economic growth and CO2 emissions. The EP coefficient is negatively significant in the Africa country group, indicating that a large number of industry employment leads to a reduction in CO2 emissions from fossil fuel energy consumption in African countries. Meanwhile, the RIR and POP coefficients are statistically insignificant.

Table 6. Moderating role of renewable energy consumption on the relationship between monetary-fiscal policy and CO2 emissions

Panel fixed effect regression (including year fixed effect with country-clustered standard errors)					
Variable	Full sample	North & South America	Europe	Africa	Asia
C	78.606***	41.189	163.120***	100.80***	76.371***
	(0.00)	(0.24)	(0.00)	(0.00)	(0.00)
MP*REN	0.005	0.018*	0.266***	0.003	0.151**
	(0.38)	(0.08)	(0.00)	(0.71)	(0.04)
FP*REN	0.019	0.078***	0.152***	-0.006	0.117
	(0.20)	(0.00)	(0.00)	(0.49)	(0.11)
MP*FP*REN	-0.001	-0.002**	-0.012***	-0.0005	-0.013*
	(0.39)	(0.02)	(0.00)	(0.49)	(0.06)
MP	0.148	0.069	-1.668**	0.103	0.603
	(0.61)	(0.79)	(0.01)	(0.93)	(0.31)
FP	-0.0501	-0.054	-1.013	0.263	0.081
	(0.83)	(0.92)	(0.27)	(0.33)	(0.77)
GDPR	0.501**	0.377**	0.212	0.018	-0.024
	(0.02)	(0.03)	(0.57)	(0.83)	(0.85)
ISI	-0.859	-2.045***	-3.554***	0.755	-0.092
	(0.12)	(0.00)	(0.00)	(0.23)	(0.91)
POP	1.013	2.558	-1.668	-0.129	0.199
	(0.14)	(0.12)	(0.48)	(0.86)	(0.71)
RIR	0.009	0.171	0.255	0.003	0.029
	(0.88)	(0.37)	(0.19)	(0.97)	(0.49)
REN	-1.212***	-1.730***	-4.237***	-0.908***	-2.241***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
EP	-0.085	0.385	-0.435*	-0.501**	0.506
	(0.57)	(0.11)	(0.05)	(0.04)	(0.16)
R^2	92.67	97.89	89.29	99.43	92.90
Adj R^2	92.25	97.17	87.10	99.22	91.18
F-statistic	220.79	134.30	40.73	459.51	53.88
P(F-statistic)	0.000	0.000	0.000	0.000	0.000

p-values are in parenthesis. ***, **,* represent statistical significance at the 1%, 5%, 10% levels.

Source: Author's own work

5.4. Moderating role of institutional quality

The literature also shows that strong institutions can mitigate the negative environmental externalities arising from economic activity (Stef et al, 2023; Boateng et al, 2024), and one of such externalities is CO2 emissions into the environment. The main argument is that effective regulatory institutions can introduce and enforce regulations that prohibit or reduce CO2 emissions into the environment (Boateng et al, 2024). Following this argument, it is expected that greater institutional quality should mitigate CO2 emissions from fossil fuel energy consumption. Therefore, in this section, the above argument is tested empirically to determine whether institutional quality moderates the relationship between monetary-fiscal policy and CO2 emissions.

The moderation analysis in table 7 shows that the MP*FP*ISI coefficient is negatively significant in the Africa country group, indicating that higher tax revenue and interest rate combined with strong institutional quality jointly reduce CO2 emissions from fossil fuel energy

consumption in African countries. This result supports Stef et al (2023) and Boateng et al (2024) who show that institutional quality mitigates CO2 emissions. In contrast, the MP*FP*ISI coefficient is insignificant in the Americas, Asia and Europe country groups, indicating that higher tax revenue, higher interest rate and higher institutional quality do not jointly reduce CO2 emissions in Asian, European and the Americas countries. Interestingly, the control variables also report the expected signs. The ISI and REN coefficients are negatively significant in the Europe group, indicating that strong institutional quality and renewable energy consumption decrease CO2 emissions from fossil fuel energy consumption. The GDPR and POP coefficients are positively significant in the Americas and Africa country groups respectively, indicating that positive economic growth and higher population size leads to higher CO2 emissions in the region of the Americas and in African countries respectively. The EP coefficient is negatively significant in the Africa country group, indicating that a large amount of industry employment leads to a reduction in CO2 emissions from fossil fuel energy consumption in African countries. Meanwhile, the RIR coefficient is statistically insignificant.

Table 7. Moderating role of institutional quality on the relationship between monetary-fiscal policy and CO2 emissions

Panel fixed effect regression (including year fixed effect with country-clustered standard errors)					
Variable	Full sample	North & South America	Europe	Africa	Asia
C	84.494***	37.043	132.55***	93.098***	87.62***
	(0.00)	(0.32)	(0.00)	(0.00)	(0.00)
MP*ISI	0.045	0.225	0.708	0.019	-0.599
	(0.77)	(0.33)	(0.32)	(0.82)	(0.32)
FP*ISI	0.089	0.367	0.655	0.213*	0.057
	(0.66)	(0.22)	(0.11)	(0.08)	(0.91)
MP*FP*ISI	0.0002	-0.025	-0.029	-0.014*	0.034
	(0.99)	(0.25)	(0.48)	(0.08)	(0.53)
MP	0.0601	-0.252*	-0.719	-0.344*	0.018
	(0.72)	(0.07)	(0.27)	(0.10)	(0.97)
FP	0.112	0.864	-0.155	-0.249	0.308
	(0.55)	(0.21)	(0.82)	(0.31)	(0.27)
GDPR	0.407**	0.850**	0.081	-0.067	0.042
	(0.01)	(0.02)	(0.83)	(0.56)	(0.82)
ISI	-2.609	-5.163	-16.701**	0.210	-0.552
	(0.27)	(0.11)	(0.03)	(0.91)	(0.92)
POP	0.635	2.212	-1.260	0.882**	-0.254
	(0.24)	(0.26)	(0.64)	(0.01)	(0.78)
RIR	0.009	-0.159	0.082	0.0002	0.029
	(0.87)	(0.46)	(0.49)	(0.99)	(0.68)
REN	-1.009***	-0.838***	-0.982***	-0.972***	-0.899***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
EP	-0.073	0.435	-0.393	-0.458**	0.399
	(0.66)	(0.42)	(0.19)	(0.02)	(0.21)
R^2	92.51	96.42	86.95	99.47	92.51
Adj R^2	92.08	95.18	84.28	99.28	90.69
F-statistic	215.75	77.67	32.54	501.54	50.88
P(F-statistic)	0.000	0.000	0.000	0.000	0.000

p-values are in parenthesis. ***,**,* represent statistical significance at the 1%, 5% and 10% levels.

Source: Author's own work

6. Conclusion

This article explored the impact of monetary and fiscal policy on CO2 emissions from fossil fuel energy consumption. The focus of analysis was regional country groups to determine how monetary and fiscal policy affect CO2 emissions in regional contexts. The study extended the literature by linking monetary and fiscal policy to the net zero emissions goal for sustainable development.

It was found that higher interest rates reduce CO2 emissions in the region of the Americas while higher taxes increase CO2 emissions in the region of the Americas. The interaction analyses showed that higher taxes and interest rates jointly reduce CO2 emissions from fossil fuel energy consumption in the regions of the Americas and Africa. It was also found that higher taxes and interest rates combined with higher renewable energy consumption jointly reduce CO2 emissions from fossil fuel energy consumption in the regions of the Americas, Asia and Europe. Also, higher taxes and interest rates combined with higher institutional quality jointly reduce CO2 emissions from fossil fuel energy consumption in African countries. Furthermore, higher renewable energy consumption reduces CO2 emissions from fossil fuel energy consumption in Africa, Asia, Europe and the Americas while institutional quality consistently reduce CO2 emissions from fossil fuel energy consumption in Europe and the Americas.

The implication of the findings is that there should be effective monetary and fiscal policy coordination to mitigate CO2 emissions in the regions examined. More specifically, the monetary and fiscal authorities should increase interest rate and taxes on the fossil fuel economy in a coordinated manner to reduce CO2 emissions from fossil fuel energy consumption. It is also recommended that the monetary and the fiscal authorities should introduce other policy initiatives that can mitigate CO2 emissions from fossil fuel energy consumption such as accelerating renewable energy investment in partnership with the private sector. However, it should also be emphasized that mitigating CO2 emissions is a fiscal issue and not a monetary issue. This means that central banks should not go all out to tackle CO2 emissions as it can distract them from their core mandate of price stability. The fiscal authorities have more capacity to introduce policies to mitigate CO2 emissions. The fiscal authorities should also strengthen existing institutions to enable them to monitor and enforce laws and regulations aimed at reducing CO2 emissions from fossil fuel energy consumption. This may involve creating new institutions, making existing institutions independent and without undue political interference or increasing the enforcement powers of existing institutions.

A limitation of this study is that it used a single indicator of monetary policy and fiscal policy rather than using multiple indicators which may offer additional insights. Another limitation is the dependent variable which is CO2 emissions from fossil fuel energy consumption. There may be other variables that better capture the level of CO2 emissions such as consumption-based CO2 emissions. Finally, some directions for future research are suggested such as the need to investigate the impact of monetary and fiscal policy on other sustainable

development goal indicators, or the effect of economic policy uncertainty on existing efforts to mitigate CO2 emissions from fossil fuel energy consumption. Future studies can also extend this research by re-examining the impact of monetary and fiscal policy on CO2 emissions in other country groups such as Oceania and using other econometric techniques or qualitative methods to gain deeper insights into the diverse ways in which monetary and fiscal policy can affect CO2 emissions.

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