–Preliminary Draft–
A Divine Coincidence? Do Renewables Shield Inflation from Fossil Fuel-price Fluctuations?

Laurent Millischer*[a], Chenxu Fu†[b], Ulrich Volz‡[c,d], and John Beirne§[b]

[a]Joint Vienna Institute (JVI)
[b]Asian Development Bank Institute (ADBI)
[c]SOAS, University of London
[d]London School of Economics and Political Science

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Abstract

This study investigates the relationship between renewable energy adoption and the sensitivity of inflation to changes in fossil fuel prices across 75 countries over a 50-year period from 1973 to 2022. In the wake of recently increased oil and gas prices leading to inflation surges, the notion of a "divine coincidence" posits that higher shares of renewable energy – on top of fighting climate change – could mitigate inflation volatility induced by fossil fuel price shocks. However, our empirical analysis does not support this hypothesis, we find no evidence that renewable energy adoption reduces the impact of fossil fuel price changes on energy inflation rates. This counter-intuitive result may be attributed to the omission of energy policies, especially price controls, in the data set, potential threshold effects in electricity prices, and trade linkage spillovers. As the world continues transitioning towards a low-carbon economy, it is crucial to understand the implications of this shift on inflation dynamics. Confirming the "divine coincidence" hypothesis in the future could significantly impact the conduct of monetary policy.

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*Corresponding author: lmillischer@jvi.org
†cfu1@adbi.org
‡uv1@soas.ac.uk
§jbeirne@adbi.org

1 Introduction

After a prolonged period of low inflation across most of the world, inflation surged in 2021 and 2022. While there are various drivers of inflation – including supply chain disruptions related to the COVID-19 pandemic and fiscal stimulus programs – the increase in oil and gas prices were a dominant factor. Schnabel (2022) notes that in February 2022 "energy accounted for more than 50% of headline inflation in the euro area , mainly reflecting the sharp increases in oil and gas prices"

This is not the first time that oil price increases cause spikes in inflation. As can be seen in Figure 1, all three episodes of high inflation (1973, 1979 and 2021) in the United States and Germany coincide with jumps in the oil price. Fluctuations in fossil fuel prices are a challenge for price stability.

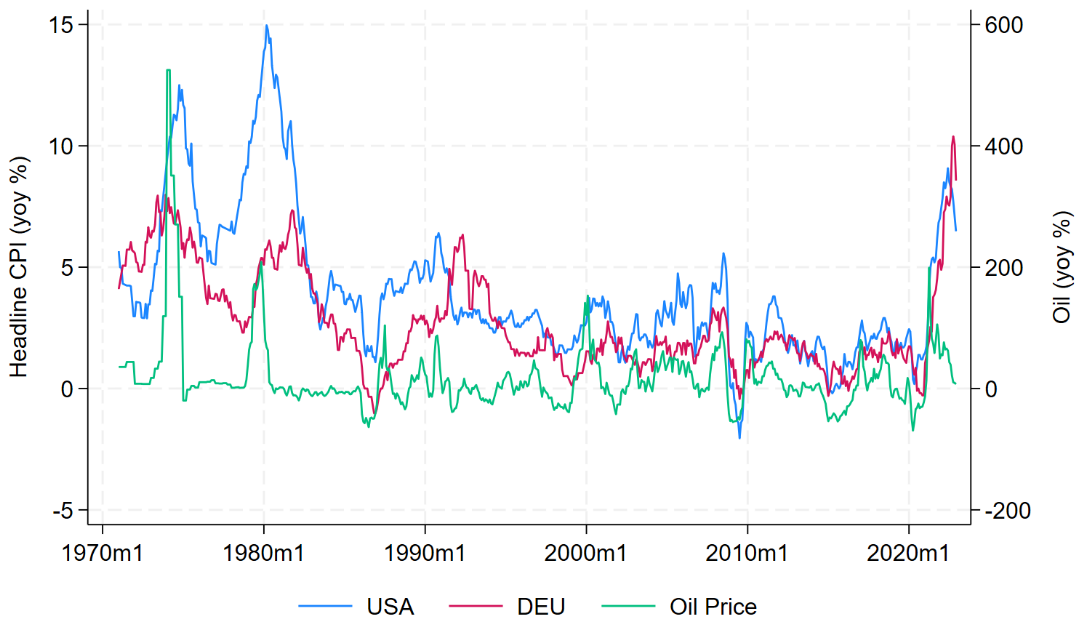

Figure 1: Monthly series of year-on-year headline inflation in the USA (blue) and Germany (red) and oil-price changes (green). All periods of high inflation (above 6%) coincide with rapid jumps in the oil price: 1973, 1979 and 2021.

There is a rich literature examining the impact of oil price shocks on inflation and inflation expectations. As pointed out by L. Kilian (2008) and others, large fluctuations in energy prices have been a distinguishing characteristic of the U.S. economy and other economies since the 1970s, with major impacts on inflation. One important insight is that oil price increases have different effects on real GDP and inflation, depending on whether they are driven by negative supply or positive demand shocks (L. Kilian, 2009; Peersman & Robays, 2012; Baumeister, 2013). Numerous studies have empirically investigated the pass-through of oil price shocks to producer and consumer prices (e.g., Chen, 2009; Clark & Terry, 2010; Gao et al., 2014; Castro & Jiménez-Rodríguez, 2017; Conflitti & Luciani, 2019; Wen et al., 2021; Baba & Lee, 2022). There is also a growing literature investigating the impacts of oil and gas prices on consumer inflation expectations (e.g., Wong, 2015, C. C. Binder, 2018, X. Z. Kilian L., 2022, C. Binder & Makridis, 2022). Recently, Ha et al. (2023) show that oil price shocks tend to contribute significantly more to inflation variation in advanced economies; countries with stronger global trade and financial linkages; commodity importers; net energy importers; countries without inflation-targeting regimes; and countries with pegged exchange rate regimes.

Erratic fossil fuel prices have not only contributed to macroeconomic volatility. The burning of fossil fuels is also the major driver of climate change (Ritchie et al., 2023a). The Intergovernmental Panel on Climate Change (IPCC) - the United Nations body for assessing the science related to climate change - clearly states that humanity urgently needs to get away from fossil fuels to limit global warming to levels that are compatible with human development (Intergovernmental Panel on Climate Change, 2022).

In light of the well-established sensitivity of inflation to changes in oil and gas prices (what Schnabel, 2022 calls "fossilflation"), it is reasonable to hypothesize that reducing the share of fossil fuels in an country's energy mix – by increasing the share of renewable and possibly nuclear energy – could mitigate the impact of oil and gas price changes on inflation. Were this hypothesis confirmed, a higher share of renewable energy would act as a "shield" against inflation volatility induced by oil price shocks, particularly in cases of sudden surges in fossil fuel prices such as those observed in 1973, 1979, or 2021.

Indeed policy makers and think-tanks have been arguing that the transition away from fossil fuels could support price stability while also fighting climate change (e.g. Heemskerk et al., 2022, Melodia, 2022, and Pous et al., 2022). Panetta (2022) calls that possible outcome a "divine coincidence".

While the "divine coincidence hypothesis" is widely discussed, we are not aware of published empirical research studying how renewable energy affects the sensitivity of inflation to changes in fossil fuel prices. Deka & Dube (2021) and Deka et al. (2022) study the interactions of renewable energy use, inflation and the exchange rate in Mexico and Brazil but do not discuss international fossil fuel prices. Ha et al. (2023) do note include renewables in their study and Akan (2023) investigates how renewables affect the impact of inflation on emissions rather than the impact of fossil fuel prices on inflation.

Our study aims to fill that gap. Using a panel data set spanning 50 years (from 1973 to 2022) and covering 75 countries, we regress energy inflation rates on a set of macroeconomic variables as well as on changes in international fossil fuel prices. By interacting the change in fossil prices with the share of renewable energy, we can estimate whether an increase of fossil prices is associated with a lower increase in energy inflation in countries with a higher share of renewable energy.

We do not find this to be true and therefore cannot confirm the divine coincidence hypothesis. That result is robust to sub-periods, country sub-samples and alternative metrics of inflation, fossil prices and renewable energy.

This result seems counter-intuitive at first. Surely when countries' reliance on fossil fuels decreases, so should the sensitivity of their inflation on fossil fuel prices. Three reasons could explain why we cannot empirically confirm the dampening effect of renewable energy on the fossil fuel price-inflation relationship in this study. First, for lack of a structured dataset, we do not account for countries' energy policies, in particular price controls. Second, there might be threshold effects, in particular for electricity prices, where in a number of countries the marginal producer (often a coal or gas-fired power plant) sets the wholesale price for the entire market. Third, trade linkage spillovers could imply that the divine coincidence hypothesis does not hold at the country level.

While the world progresses in the transition to a low-carbon economy and wanes itself off fossil fuels, more work is required to understand the impact the transition will have on inflation. Should the divine coincidence hypothesis be confirmed in the future and renewable energy expansion have a positive effect both on climate change mitigation and on price stability, this would have a bearing on the conduct of monetary policy and the greening of the monetary policy toolkit.

The remainder of the paper is structured as follows. The next section presents a simple model of energy prices and inflation. Section 3 describes the data sources, aggregation process and the sample. Section 4 present the empirical strategy and results. Finally, Section 5 discusses the results and concludes.

2 A simple model of energy prices and inflation

Inflation, the yearly rate of change of the consumer price index (or a sub-index thereof), is computed as follows:[1]

$$\pi = \sum_i w_i \frac{p_i^Y - p_i^{Y-1}}{p_i^{Y-1}} = \sum_i w_i \pi_i \tag{1}$$

where π is the (E)CPI inflation, w_i is the weight of item i in the underlying consumption basket, p_i^Y (p_i^{Y-1}) is the price of item i in year Y ($Y-1$) and $\pi_i = (p_i^Y - p_i^{Y-1})/p_i^{Y-1}$ is the price increase of item i over the span of a year.

In order to compare the impact of a fossil energy price shock on inflation of two countries "RE" (with a high share of renewable energy) and "F" (for fossil, i.e. having low share of renewable energy), one can write the difference in inflation impacts as:

$$\Delta\pi^{RE} - \Delta\pi^F = \sum_i (w_i^{RE}\Delta\pi_i^{RE} - w_i^F \Delta\pi_i^F) \tag{2}$$

where $\Delta\pi$ is the fossil energy price shock-induced impact on inflation. Equation (2) can be re-written as:

$$\Delta\pi^{RE} - \Delta\pi^F = \sum_i (\underbrace{w_i^{RE}\left[\Delta\pi_i^{RE} - \Delta\pi_i^F\right]}_{\text{[P] price effect}} + \underbrace{\left[w_i^{RE} - w_i^F\right]\Delta\pi_i^F}_{\text{[W] weight effect}}) \tag{3}$$

Equation (3) shows that a lower inflation impact in the high-renewables country RE could stem from two effects, a price and a weight effect.

Price effect

Assuming all items have equal weight in the consumption baskets of the two countries, term [W] in equation (3) would be equal to zero (as $w_i^{RE} = w_i^F$) and $\Delta\pi^{RE}$ would be lower than $\Delta\pi^F$ if the inflation impact on the dominant items were lower in RE (in mathematical terms: $\sum_i w_i \left[\Delta\pi_i^{RE} - \Delta\pi_i^F\right] < 0$).

Figure 2 illustrates this possible effect. When considering the impact of a fossil fuel price shock on different items of the energy consumption basket, one could expect the impact on some items to be lower in countries with a high share of renewable energies. For instance, in a country with a high share of gas in the power production, the impact on power prices (item 2 on Figure 2) would be expected to be higher than in a country producing most of

[1] In most countries, when looking at December to December inflation rates, the weights of individual items in the consumption basked are not updated and equation (1) holds.

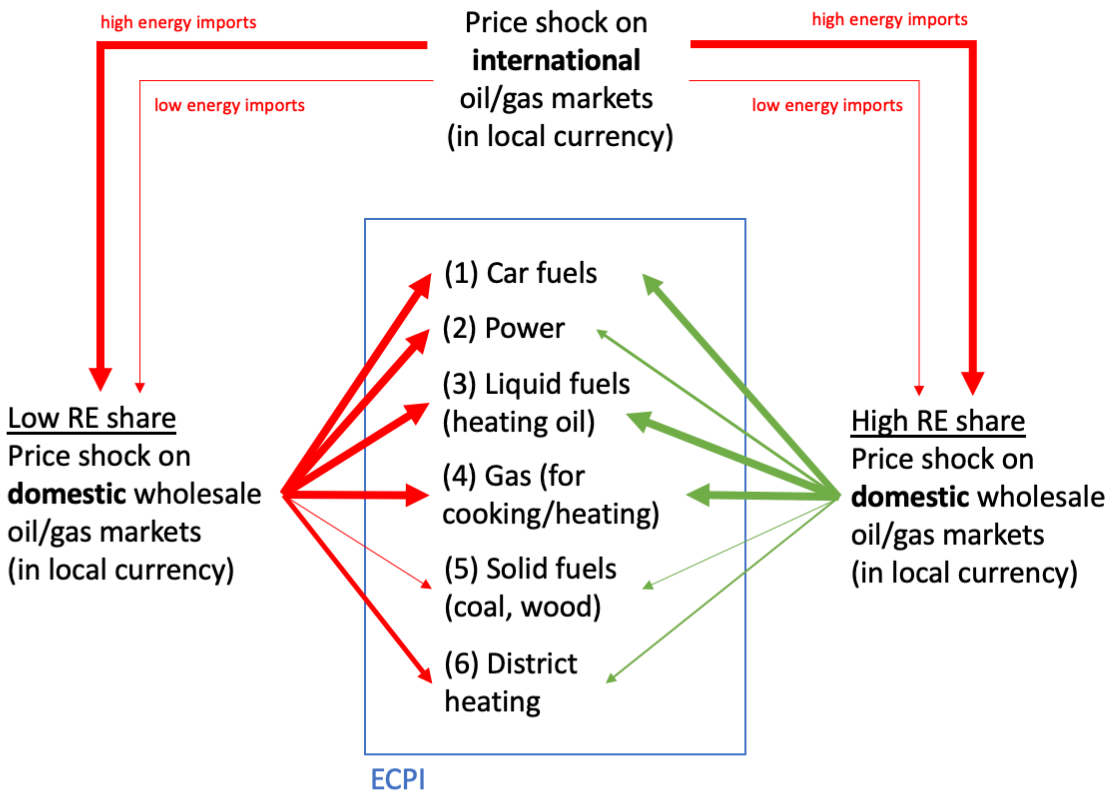

Figure 2: Impact of a fossil energy price shock on international markets on domestic energy (ECPI) inflation. The arrow width represents the magnitude of the price impact. Green (red) arrows represent price impacts on individual ECPI items for a country with a high (low) share of renewable energy in its energy mix.

its power from hydroelectric, solar and wind.

Weight effect

On the other hand, assuming all items saw identical inflation impacts in both countries, term [P] in equation (3) would be equal to zero (as $\Delta\pi_i^{RE} = \Delta\pi_i^F$) and $\Delta\pi^{RE}$ would be lower than $\Delta\pi^F$ if the highest-inflation items had lower weights in the consumption basket of country RE (in mathematical terms: $\sum_i \left[w_i^{RE} - w_i^F\right] \Delta\pi_i < 0$).

This effect can be illustrated with Figure 2. Assuming the impact of international fossil fuel prices on solid fuels such as wood and coal (item 5) were lower than on other items in the energy consumption basket, then a country with a high share of renewables in its energy mix driven by a high share of biomass (wood) in heating would experience a lower energy inflation in the face of a shock on international energy markets than an otherwise comparable country. This would not be driven by a lower inflation of any of the items but by a higher weight of item 5 and a lower weight of, e.g., items 4 (heating gas) and 6 (district heating).

While the disentangling of the two effects is not presented in the current version of this paper, it will be added in a subsequent version.

3 Data

This section outlines the main data series used in the empirical exercises. Section 3.1 presents the data sources, Section 3.2 discusses how we compute the change of fossil-fuel prices for each country and Section 3.3 presents stylized facts.

3.1 Data Sources

Inflation. Our inflation measures are drawn from Ha et al. (2021) that comprehensively documents various types of inflation measures for 37 advanced economies (AEs) and 159 emerging markets and developing economies (EMDEs) for 1970-2022. More importantly, not only the overall CPI is reported, data of energy CPI, core CPI, food CPI and PPI are available in an unbalanced panel. In this analysis we will focus on the energy CPI and analyse how it is affected by changes in international fossil fuel prices.

Not only inflation, we also look into CPI inflation forecast for which the data is obtained from the IMF Historical World Economic Outlook (WEO) Forecasts Database.[2] This data is available bi-annually for 194 countries since 1990.

Renewable Energy (RE). Renewable energy share is the main variable of our interest as it could potentially shield a country's inflation from international energy price fluctuations. Ritchie et al. (2023b) combines data from major energy-related databases such as British Petroleum (BP), International Energy Agency (IEA) and others. Renewable energy is measured either as a share in energy consumption and in electricity production. Particularly renewable energy includes energy from wind, solar, hydro and others whereas fossil fuel contains coal, gas and oil. Besides, we also use the share of nuclear energy from this database to test if the divine coincidence might hold when considering low-carbon energy sources (the sum of renewables and nuclear).

Energy Price. International energy price is sourced from the World Bank Commodity Price Database (the "Pink Sheet").[3] This energy price index is a weighted average prices of crude oil (84.6%), natual gas (10.8%) and coal (4.7%). Exchange rate per US dollar from the Bank of International Settlement (BIS)[4] is applied to convert the international energy price into local currency for each country.

Energy Import. Another critical component in our analysis is whether a country is a large importer of energy from the international market. To calculate the share of the renewable and fossil as of total energy import, data is drawn from the World Energy Balance

[2]https://www.imf.org/external/pubs/ft/weo/data/WEOhistorical.xlsx

[3]https://www.worldbank.org/en/research/commodity-markets

[4]https://www.bis.org/statistics/full_xru_csv.zip

by the IEA. Additionally, net energy import as percentage of energy use is taken from the World Bank to categorize each country into either a high energy importer, low importer or exporter.[5]

Fossil Fuel Subsidies. Fuel subsidy data is taken from the Fossil Fuel Subsidy Tracker that is jointly published by the OECD and International Institute for Sustainable Development (IISD). This data is widely available for 185 countries from 2010 to 2021. Specifically, total subsidy as a percentage of GDP is computed for each country and used as a proxy for price rigidity policy in the analysis later.

3.2 Change in fossil fuel prices

As discussed in Section 1, international fossil fuel price changes are strongly correlated with domestic (energy) inflation. Nonetheless, the final price for each country differs from the international market due to factors such as exchange rate, energy imports, or energy mix used domestically. Therefore, an energy price index is built for countries in our sample that captures above factors. Specifically, we start by building a country-relevant international fossil energy price index (by weighting oil and gas prices according to their share in that country's consumption and – for gas prices – by considering the geographically closest available gas exchange price) which is then converted to local currency. For countries without the energy mix data, price index in local currency is then used.

As shown in Figure 3, the country-specific fossil fuel price changes broadly follow the dynamics of the international fossil fuel price, although there is a larger distributions across countries due to weighting and exchange rate fluctuations.

3.3 Stylized Facts

Table 1 summarizes the data statistics of main variables used in the analysis across countries and time horizon. Three variables (inflation, fossil fuel price changes, energy imports) exhibit very broad distributions with big upward or downward outlier observations, reflecting periods of hyperinflation and massive currency devaluation. These extreme values will have to be appropriately taken care of in the empirical analysis. Table 2 shows the correlations among the main variables. The share of renewable energy is not correlated with inflation rates.

Before diving into the impact of renewable energy and energy imports, we first confirm that fossil fuels make up almost all the energy import for countries. In our sample , Figure 4 shows that all countries import at least 97% fossil of total energy import in 1980 whereas renewable energy accounted for almost none. Although fossil import share decreased over

[5] Net energy import data was discontinued in 2015, so we carry forward the latest observation.

Figure 3: Local energy price and international price

four decades, it still accounts for over 92% of total energy import in 75% of countries in 2020. In comparison, renewable energy import is below 2% in most countries despite an increase in the past decades.

Lastly, Figure 5 shows the energy inflation across countries since 1970. There are two clear hikes during the oil crisis in the 1970s and most recently, the energy price shock after 2021.

Table 1: Summary statistics. All units are [%] with the exception of GDP per capita.

	Mean	sd	Min	P25	P50	P75	Max	N
Headline inflation	54.5	1,120.8	-28	2.1	4.8	10.9	65,374	3,867
Energy inflation	60.3	1,685.1	-128	1.8	4.9	12.1	94,802	3,311
Energy price change	44.9	40.3	2	16.8	30.9	69.4	153	4,622
RE in consumption	10.1	13.6	0	0.9	4.9	13.3	87	4,977
LC in consumption	13.0	15.3	0	1.8	7.7	18.6	87	4,977
Net energy import	-141.2	1,059.4	-17,633	-29.5	26.8	63.0	100	4,914
Output gap	1.3	34.0	-51	-3.4	0.0	3.2	2,038	4,111
GDP per capita	8.5	1.6	3	7.3	8.6	9.8	12	4,172
Fossil subsidy	0.0	0.0	0	0.0	0.0	0.0	0	927

Table 2: Cross-correlation table

	1	2	3	4	5	6	7	8	9
1 Headline inflation	1.00								
2 Energy inflation	0.96	1.00							
3 Energy price index	-0.01	0.00	1.00						
4 RE in consumption	0.02	0.01	0.08	1.00					
5 LC in consumption	0.01	0.00	0.14	0.90	1.00				
6 Net energy import	0.00	-0.01	0.10	0.08	0.10	1.00			
7 Output gap	-0.03	-0.02	-0.00	-0.03	-0.03	-0.03	1.00		
8 GDP per capita	-0.06	-0.03	0.45	0.16	0.28	0.03	0.00	1.00	
9 Fossil subsidy	0.02	0.03	0.14	-0.27	-0.31	-0.24	0.03	-0.06	1.00

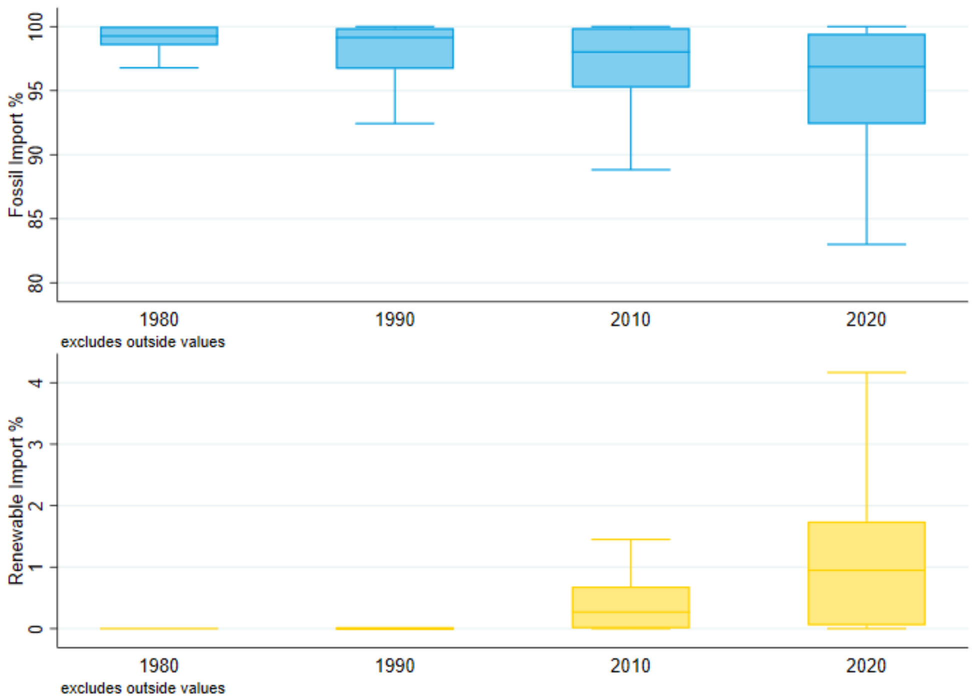

Figure 4: Import shares of fossil and renewable

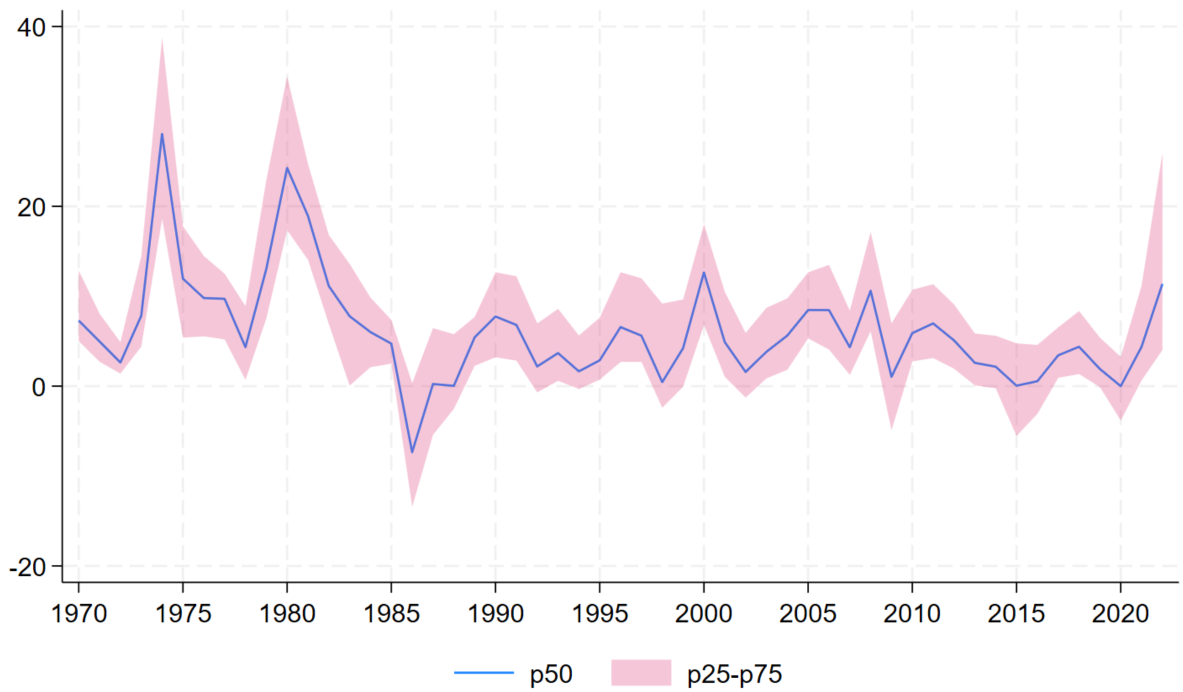

Figure 5: ECPI over time %

4 Empirical Results

4.1 Yearly regressions

In order to capture the co-movements of international energy prices and energy inflation and see whether these are modulated by a country's fraction of renewable energy, we estimate the following OLS panel regression with year-on-year data:

$$\pi^e_{i,Y} = \Delta E_{i,Y} + X_{i,Y} + \Delta E_{i,Y} \times X_{i,Y} + \mathrm{g}_{i,Y} + \mathrm{YC}_{i,Y} + \mathbb{E}\pi_{i,Y} + C_i \tag{4}$$

where $\pi^e_{i,Y}$ is the energy inflation[6] of country i in year Y, $\Delta E_{i,Y}$ is the percentage change in international fossil fuel prices expressed in local currency for country i in year Y,[7] $X_{i,Y}$ is the modulating variable, e.g. the share of renewables in country i's energy consumption in year Y. Further, $g_{i,Y}$ is the output gap[8], $YC_{i,Y}$ is the per capita GDP[9], $\mathbb{E}\pi_{i,Y}$ the expected inflation[10] of country i in year Y and C_i are country fixed effects. In order to avoid the regression results to be driven by those observations corresponding to hyper-inflation or extreme devaluation (see Table 1 showing the extreme outliers), both $\pi^e_{i,Y}$ and $\Delta E_{i,Y}$ have been winsorized at 150% . The main results are robust to dropping instead of winsorizing outlier observations.

Table 3 presents the regression results. Column (1) shows the results of the simplest regression obtained when omitting the modulating variable in equation (4). The parameter in front of $\Delta E_{i,Y}$ is highly significant and positive: an increase in local-currency fossil fuel prices of 1% is associated with an increase of energy inflation of 0.109% in the same year. The parameters of the macro controls (output gap, per-capital GDP and expected inflation) are significant and exhibit the economically intuitive signs. Indeed, a high output gap is associated with higher energy inflation as are higher inflation expectations. Higher per capital GDP (a proxy for increased institutional quality) is associated with lower energy inflation.

Column (2) presents the results of the regression when using the share of renewable energy (RE) in total energy consumption as the modulating variable $X_{i,Y}$. The parameter in front of $\Delta E_{i,Y}$ is still highly significant and positive,[11] but the parameters in front of the renewable share (X) and the interaction term of $\Delta E_{i,Y}$ and the renewable share are

[6] The growth rate of the consumption basket of energy products as described in Section 3.

[7] Section 3.2 describes how $\Delta E_{i,Y}$ is constructed.

[8] Computed as the percentage gap of real GDP to its Hodrick-Prescott filtered trend.

[9] Per capita GDP is included in the regression as a proxy for economic and institutional development.

[10] The expected inflation is proxied by the average headline inflation of years $Y-1$, $Y-2$ and $Y-3$.

[11] An increase in local-currency fossil fuel prices of 1% is associated with an increase of energy inflation of 0.123% in the same year.

not statistically significantly different from 0. A higher share of renewables in total energy consumption of a country is therefore not associated with a lower energy inflation increase in the face of an increase in international energy prices. Had that been true, the divine coincidence hypothesis would have been confirmed.

Column (3) in Table 3 present the results of the regression using the fraction of low-carbon energy in the total energy consumption as the modulating variable $X_{i,Y}$. Low-carbon energy is defined here as the sum of renewable and nuclear energy. We run this regression to test a different version of the divine coincidence hypothesis. Indeed it could be envisaged that countries can decouple their energy inflation from fluctuations of international fossil fuel prices by increasing the share of non-fossil or low-carbon energy sources (including renewables and nuclear). Empirically however, a higher consumption of low-carbon energy is not associated with a higher or lower energy inflation in the face of an increase in international energy prices – the relevant parameter ($\Delta E \times X$) are found not to be significantly different from 0.

Column (4) shows the regression results obtained when using net energy imports[12] as the modulating variable $X_{i,Y}$. Again the relevant parameter ($\Delta E \times X$) is found not to be significantly different from 0. The level of energy imports does not significantly modulate the co-movement of energy prices and energy inflation.

Finally, we wanted to study whether a higher consumption of renewable energy was associated with a weaker co-movement of energy inflation and international energy prices when also controlling for energy imports. Indeed, it could be possible that the benefits of the divine coincidence extend to different degrees to net energ importers and exporters. We therefore introduced two modulating variables (X^A net energy imports and X^B the share of renewables in energy consumption) as described in equation (5) below.[13]

$$\pi^e_{i,Y} = \Delta E_{i,Y} + X^A_{i,Y} + \Delta E_{i,Y} \times X^A_{i,Y} + X^B_{i,Y} + \Delta E_{i,Y} \times X^B_{i,Y} + ... \quad (5)$$

Column (5) in Table 3 shows that the parameters of both modulating variables are not statistically different from 0 and that therefore a higher consumption of renewable energy is not associated with a weaker co-movement of energy inflation and international energy prices when controlling for energy imports. The results are robust to using a categorical control of net energy imports rather than the continuous variable.[14]

[12]Net energy imports (defined as imports minus exports as a fraction of total domestic energy consumption) can be negative when a country exports more energy than it imports. As some countries export a multiple of their domestic consumption, we winsorized the variable at -100%. The result still holds when dropping the high values.

[13]The same macro controls as in equation (4) were used.

[14]We have used two categories (net importing and net exporting countries), three categories (high im-

porters with more than 50% of energy consumption imported, low net importers with less than 50% imported and net exporters) and quintiles of net energy exports.

Table 3: Yearly regression

	(1)	(2)	(3)	(4)	(5)
		RE	LC		RE
GDP per capita (YC)	-2.103***	-1.781**	-1.640**	-2.128***	-1.764**
	(0.434)	(0.588)	(0.596)	(0.492)	(0.587)
Output gap (g)	0.100**	0.137*	0.131*	0.099*	0.138*
	(0.036)	(0.056)	(0.055)	(0.047)	(0.057)
Inflation expectation ($\mathbb{E}\pi$)	0.515***	0.576***	0.576***	0.505***	0.573***
	(0.067)	(0.088)	(0.088)	(0.070)	(0.088)
ΔE	0.109***	0.123***	0.118***	0.115***	0.119***
	(0.009)	(0.017)	(0.018)	(0.011)	(0.017)
X		0.058	-0.027		0.069
		(0.079)	(0.052)		(0.080)
$\Delta E \times$ X		0.001	0.001		0.001
		(0.001)	(0.001)		(0.001)
Net import				0.010	0.021
				(0.022)	(0.026)
$\Delta E \times$ Net import				0.000	0.000
				(0.000)	(0.000)
Country FE	Y	Y	Y	Y	Y
Cluster	cty	cty	cty	cty	cty
R^2	0.44	0.50	0.50	0.45	0.50
Country-Year	5,888	2,940	2,940	4,688	2,940
Countries	170	75	75	128	75
Countries: AE	35	33	33	34	33
Countries: EM	86	39	39	67	39
Countries: LIC	49	3	3	27	3
Start	1973	1973	1973	1973	1973
End	2022	2022	2022	2022	2022

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Introducing lags

When international fossil fuel prices rise, the price of retail energy products[15] does not rise immediately. Indeed, wholesale or retail contracts often lock in prices over some period and readjust at set dates. The impact of an increase in international prices therefore takes time to "feed through" to energy inflation. In order to account for this mechanism, we have introduced lags of the energy-price change in the regression as shown in equation (6).

$$\pi^e_{i,Y} = X^A_{i,Y} + \sum_{k=0}^{k=N} \left[\Delta E_{i,Y-k} + \Delta E_{i,Y-k} \times X^A_{i,Y}\right] + ... \tag{6}$$

where $\Delta E_{i,Y-N}$ is the Nth lagged change in international energy prices, which is also interacted with the modulating variable $X_{i,Y}$ (the share of renewables or low-carbon sources in final energy consumption). The same macro controls as in equation (4) were used.

Table 4 presents the results. Column (1) shows the results of the simple regression without modulating variable. The parameter in front of ΔE and the two lags $L.\Delta E$ and $L2.\Delta E$ are highly significant and positive: an increase in local-currency fossil fuel prices of 1% is associated with an increase of energy inflation of 0.105% in the same year, 0.068% in the next year and 0.020% in the year after that. The third lag is no longer significant. The parameters of the macro controls (output gap, per-capital GDP and expected inflation) are significant and exhibit the economically intuitive signs.

Column (2) presents the results when introducing the share of renewables (RE) in total energy consumption as the modulating variable. None of the three interaction terms[16] is significant, meaning that a higher share of renewables in the energy mix is not associated with a lower fossil fuel-induced increase in energy inflation. This is true in the year of the fossil fuel price increase as well as in the two subsequent years.

Column (3) shows the regression outcome when using the share of low-carbon energy in total energy consumption as modulating variable. The results are very close to those of the renewable energy consumption[17] with the contemporaneous and one-lag interaction terms not significant. The two-lag interaction term is negative and statistically significant with 95% confidence. The economic significance however is very weak however. While a 1% increase in international fossil fuel prices in year Y would be associated with a cumulative increase of retail energy prices of 0.255% over a three year horizon[18], a country with a 1% higher share in renewables would see its retail energy prices increase by 0.252% over the

[15] The energy consumption basket typically includes transportation fuels, electricity, gas (for cooking and heating), solid fuels (such as wood and coal), liquid fuels (heating oil) and heat (such as district heating).

[16] $\Delta E \times X$, $L.\Delta E \times X$, $L2.\Delta E \times X$

[17] This is not surprising as the two variables are strongly correlated.

[18] This is the sum of parameters for ΔE, $L.\Delta E$ and $L2.\Delta E$: $0.115 + 0.08 + 0.06 = 0.255$

same three-year period.[19]

In column (4) we show the results when using net imports as the modulating variable. As above, only the two-lag interaction term is statistically significant with 95% confidence but with no economic significance. Similarly in column (5), when controlling for both the share of renewables in total energy consumption and net energy imports, we find either no statistical significance or, where we do, only a very weak economic significance on lagged interaction terms.

To summarize, even when considering lags of fossil fuel prices in order to account for the slow feed-through from international wholesale to domestic retail prices, we cannot empirically confirm the divine coincidence hypothesis. Higher shares of renewables or low-carbon energy sources are not associated with a lower fossil-fuel induced inflation volatility.

[19] That is because the parameter for $L2.\Delta E \times LC$ is -0.003

Table 4: Yearly regression with lags

	(1)	(2) RE	(3) LC	(4)	(5) RE
GDP per capita (YC)	-1.627***	-1.184	-1.074	-1.680**	-1.174
	(0.460)	(0.612)	(0.618)	(0.527)	(0.619)
Output gap (g)	0.081*	0.117*	0.110	0.075	0.114
	(0.037)	(0.057)	(0.057)	(0.048)	(0.060)
Inflation expectation ($\mathbb{E}\pi$)	0.464***	0.531***	0.528***	0.455***	0.530***
	(0.069)	(0.082)	(0.084)	(0.071)	(0.082)
ΔE	0.105***	0.117***	0.115***	0.111***	0.116***
	(0.009)	(0.016)	(0.018)	(0.011)	(0.017)
L.ΔE	0.068***	0.079***	0.080***	0.069***	0.075***
	(0.007)	(0.015)	(0.016)	(0.008)	(0.014)
L2.ΔE	0.020**	0.056**	0.060**	0.022**	0.060**
	(0.006)	(0.018)	(0.019)	(0.008)	(0.019)
X		0.075	0.019		0.074
		(0.085)	(0.056)		(0.087)
ΔE × X		0.001	0.001		0.001
		(0.001)	(0.001)		(0.001)
L.ΔE × X		-0.000	-0.000		-0.000
		(0.001)	(0.001)		(0.001)
L2.ΔE × X		-0.003	-0.003*		-0.003*
		(0.002)	(0.001)		(0.002)
Net import				0.005	0.011
				(0.023)	(0.025)
ΔE × Net import				0.000	0.000
				(0.000)	(0.000)
L.ΔE × Net import				0.000	0.000*
				(0.000)	(0.000)
L2.ΔE × Net import				-0.000*	-0.000
				(0.000)	(0.000)
Country FE	Y	Y	Y	Y	Y
Cluster	cty	cty	cty	cty	cty
R^2	0.45	0.51	0.51	0.46	0.51
Country-Year	5,871	2,926	2,926	4,671	2,926
Countries	170	75	75	128	75
Countries: AE	35	33	33	34	33
Countries: EM	86	39	39	67	39
Countries: LIC	49	3	3	27	3
Start	1973	1973	1973	1973	1973
End	2022	2022	2022	2022	2022

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Robustness

As shown in the tables in the appendix, the results presented above are robust when using robust standard errors instead of clustering at the country level (Table 5) as well as to dropping outliers instead of winsorizing (Table 6 shows that the interaction terms exhibit statistical significance but no economic significance). The results are also robust to considering a different definition of fossil fuel price changes instead of the baseline definition described in Section 3.2 (Table 7 shows the results when not accounting for the weight and origin of gas prices in the fossil fuel price index). They are further robust to considering the shares of renewables and nuclear in electricity production rather than in total energy consumption (Table 8) as well as considering different sub-regions (Table 9), sub-periods, and inflation metrics.

5 Discussion

Policy makers and experts have been arguing that the transition away from fossil fuels could support price stability while also fighting climate change. Panetta (2022) calls that possible outcome a "divine coincidence". While the "divine coincidence hypothesis" is widely discussed, we are not aware of published empirical research studying how renewable energy affects the sensitivity of inflation to changes in fossil fuel prices.

Our study aims to fill that gap. Using a panel data set spanning 50 years (from 1973 to 2022) and covering 75 countries, we regress energy inflation rates on a set of macroeconomic variables as well as on changes in international fossil fuel prices. By interacting the change in fossil prices with the share of renewable energy, we can estimate whether an increase of fossil prices is associated with a lower increase in energy inflation in countries with a higher share of renewable energy.

We do not find this to be true and therefore cannot confirm the divine coincidence hypothesis. That result is robust to sub-periods, country sub-samples and alternative metrics of inflation, fossil prices and renewable energy.

This result seems counter-intuitive at first. Surely when countries' reliance on fossil fuels decreases, so should the sensitivity of their inflation on fossil fuel prices. Three reasons could explain why we cannot empirically confirm the dampening effect of renewable energy on the fossil fuel price-inflation relationship in this study.

One possibility could be for the effect to be drowned in countries' energy policies, which we were not able to include in our regression for data-availability reasons. Indeed, market liberalization, long-term price agreements or price controls are often employed but were not available to us in a structured data set which could have been included in the empirical analysis.

Another reason for failing to empirically confirm the divine coincidence hypothesis could be the existence of threshold effects, in particular for electricity prices, where – depending on the market design – the domestic market price is often driven by the marginally producing power plant. As long as that plant is powered with fossil fuels (which is the case in most countries), the entire domestic power price would be driven by fossil fuel prices.

A third possibility could be that the divine coincidence hypothesis simply does not hold at the country level, because of trade linkages and spillovers. A country covering all of its domestic energy consumption with renewable energy would see the international demand for its renewable electricity, heating biomass and biofuels increase significantly in the face of an oil price shock as its fossil fuel-dependent trading partners look for cheaper sources of energy. This would lead domestic energy prices to increase, which would eventually feed through to other prices and increase headline inflation. In this case the divine coincidence would hold at global level only, but not at the level of individual countries.

While the world progresses in the transition to a low-carbon economy and wanes itself of fossil fuels, more work is required to understand the impact the transition will have on inflation. Should the divine coincidence hypothesis be confirmed in the future and renewable energy expansion have a positive effect both on climate change mitigation and on price stability, this would have a bearing on the conduct of monetary policy and the greening of the monetary policy toolkit.

Declaration of Competing Interest

The authors report no potential conflict of interest.

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A Appendix

A.1 Yearly regressions

Table 5: Annual regression robust: cluster year: 7_annual_202300823 03.do

	(1)	(2) RE	(3) LC	(4)	(5) RE
GDP per capita (YC)	-1.627**	-1.184*	-1.074*	-1.680**	-1.174*
	(0.513)	(0.490)	(0.498)	(0.534)	(0.492)
Output gap (g)	0.081*	0.117*	0.110*	0.075*	0.114*
	(0.031)	(0.047)	(0.046)	(0.037)	(0.045)
Inflation expectation ($\mathbb{E}\pi$)	0.464***	0.531***	0.528***	0.455***	0.530***
	(0.043)	(0.048)	(0.048)	(0.044)	(0.048)
ΔE	0.105***	0.117***	0.115***	0.111***	0.116***
	(0.012)	(0.016)	(0.016)	(0.012)	(0.016)
L.ΔE	0.068***	0.079***	0.080***	0.069***	0.075***
	(0.012)	(0.021)	(0.022)	(0.012)	(0.021)
L2.ΔE	0.020	0.056**	0.060**	0.022	0.060**
	(0.012)	(0.019)	(0.021)	(0.013)	(0.020)
X		0.075	0.019		0.074
		(0.116)	(0.075)		(0.110)
ΔE × X		0.001	0.001		0.001
		(0.001)	(0.001)		(0.001)
L.ΔE × X		-0.000	-0.000		-0.000
		(0.001)	(0.001)		(0.001)
L2.ΔE × X		-0.003**	-0.003**		-0.003**
		(0.001)	(0.001)		(0.001)
Net import				0.005	0.011
				(0.015)	(0.020)
ΔE × Net import				0.000	0.000
				(0.000)	(0.000)
L.ΔE × Net import				0.000	0.000
				(0.000)	(0.000)
L2.ΔE × Net import				-0.000*	-0.000
				(0.000)	(0.000)
Country FE	Y	Y	Y	Y	Y
Cluster	year	year	year	year	year
R^2	0.45	0.51	0.51	0.46	0.51
Country-Year	5,871	2,926	2,926	4,671	2,926
Countries	170	75	75	128	75
Countries: AE	35	33	33	34	33
Countries: EM	86	39	39	67	39
Countries: LIC	49	3	3	27	3
Start	1973	1973	1973	1973	1973
End	2022	2022	2022	2022	2022

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: Annual regression robust: drop outliers: 7_annual_20230823 09.do

	(1)	(2) RE	(3) LC	(4)	(5) RE
GDP per capita (YC)	-1.113**	-0.443	-0.399	-1.138**	-0.430
	(0.335)	(0.429)	(0.434)	(0.372)	(0.424)
Output gap (g)	0.050	0.119**	0.119**	0.037	0.106*
	(0.028)	(0.045)	(0.045)	(0.034)	(0.045)
Inflation expectation ($\mathbb{E}\pi$)	0.368***	0.515***	0.515***	0.339***	0.513***
	(0.068)	(0.081)	(0.081)	(0.069)	(0.082)
ΔE	0.078***	0.072***	0.070***	0.076***	0.067***
	(0.007)	(0.012)	(0.014)	(0.007)	(0.011)
L.ΔE	0.046***	0.046***	0.045***	0.041***	0.040***
	(0.005)	(0.010)	(0.012)	(0.006)	(0.010)
L2.ΔE	0.015**	0.027**	0.032***	0.014*	0.028**
	(0.005)	(0.008)	(0.009)	(0.006)	(0.008)
X		0.160**	0.105*		0.156**
		(0.048)	(0.041)		(0.047)
$\Delta E \times$ X		0.001**	0.001**		0.001**
		(0.000)	(0.000)		(0.000)
L.$\Delta E \times$ X		0.000	0.000		0.000
		(0.000)	(0.000)		(0.000)
L2.$\Delta E \times$ X		-0.001***	-0.001***		-0.001***
		(0.000)	(0.000)		(0.000)
Net import				0.004	0.009
				(0.012)	(0.014)
$\Delta E \times$ Net import				0.000***	0.000*
				(0.000)	(0.000)
L.$\Delta E \times$ Net import				0.000***	0.000***
				(0.000)	(0.000)
L2.$\Delta E \times$ Net import				-0.000	-0.000*
				(0.000)	(0.000)
Country FE	Y	Y	Y	Y	Y
Cluster	cty	cty	cty	cty	cty
R^2	0.30	0.30	0.30	0.30	0.32
Country-Year	4,836	2,423	2,423	3,851	2,423
Countries	168	74	74	126	74
Countries: AE	35	33	33	34	33
Countries: EM	86	39	39	67	39
Countries: LIC	47	2	2	25	2
Start	1973	1973	1973	1973	1973
End	2022	2022	2022	2022	2022

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7: Annual regression robust: dEP local only: 7_annual_20230823 05.do

	(1)	(2) RE	(3) LC	(4)	(5) RE
GDP per capita (YC)	-1.621***	-1.178	-1.068	-1.674**	-1.176
	(0.460)	(0.615)	(0.621)	(0.527)	(0.622)
Output gap (g)	0.084*	0.124*	0.116	0.079	0.123*
	(0.037)	(0.059)	(0.059)	(0.048)	(0.061)
Inflation expectation ($\mathbb{E}\pi$)	0.463***	0.530***	0.528***	0.454***	0.529***
	(0.069)	(0.082)	(0.084)	(0.071)	(0.082)
ΔE (LCU)	0.106***	0.119***	0.116***	0.112***	0.117***
	(0.009)	(0.017)	(0.018)	(0.011)	(0.018)
L.ΔE (LCU)	0.066***	0.076***	0.077***	0.067***	0.072***
	(0.006)	(0.014)	(0.016)	(0.008)	(0.014)
L2.ΔE (LCU)	0.020**	0.057**	0.061**	0.023**	0.060**
	(0.006)	(0.019)	(0.020)	(0.008)	(0.019)
X		0.077	0.020		0.077
		(0.086)	(0.057)		(0.088)
ΔE (LCU) $\times$ X		0.001	0.001		0.001
		(0.001)	(0.001)		(0.001)
L.ΔE (LCU) $\times$ X		-0.000	-0.000		-0.000
		(0.001)	(0.001)		(0.001)
L2.ΔE (LCU) $\times$ X		-0.003	-0.003*		-0.003
		(0.002)	(0.001)		(0.002)
Net import				0.006	0.013
				(0.023)	(0.025)
ΔE (LCU) $\times$ Net import				0.000	0.000
				(0.000)	(0.000)
L.ΔE (LCU) $\times$ Net import				0.000	0.000*
				(0.000)	(0.000)
L2.ΔE (LCU) $\times$ Net import				-0.000*	-0.000
				(0.000)	(0.000)
Country FE	Y	Y	Y	Y	Y
Cluster	cty	cty	cty	cty	cty
R^2	0.45	0.51	0.51	0.46	0.51
Country-Year	5,871	2,926	2,926	4,671	2,926
Countries	170	75	75	128	75
Countries: AE	35	33	33	34	33
Countries: EM	86	39	39	67	39
Countries: LIC	49	3	3	27	3
Start	1973	1973	1973	1973	1973
End	2022	2022	2022	2022	2022

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Annual regression robust: RE elec: 7_annual_20230823 07.do

	(1)	(2) RE	(3) LC	(4)	(5) RE
GDP per capita (YC)	-1.627***	-1.607***	-1.611***	-1.680**	-1.664**
	(0.460)	(0.455)	(0.458)	(0.527)	(0.515)
Output gap (g)	0.081*	0.080*	0.081*	0.075	0.075
	(0.037)	(0.036)	(0.036)	(0.048)	(0.047)
Inflation expectation ($\mathbb{E}\pi$)	0.464***	0.470***	0.469***	0.455***	0.464***
	(0.069)	(0.065)	(0.066)	(0.071)	(0.065)
ΔE	0.105***	0.109***	0.103***	0.111***	0.117***
	(0.009)	(0.013)	(0.014)	(0.011)	(0.016)
L.ΔE	0.068***	0.067***	0.063***	0.069***	0.068***
	(0.007)	(0.011)	(0.012)	(0.008)	(0.013)
L2.ΔE	0.020**	0.046***	0.050***	0.022**	0.061***
	(0.006)	(0.013)	(0.014)	(0.008)	(0.016)
X		0.022	0.009		0.046
		(0.025)	(0.025)		(0.025)
ΔE × X		-0.000	0.000		-0.000
		(0.000)	(0.000)		(0.000)
L.ΔE × X		0.000	0.000		0.000
		(0.000)	(0.000)		(0.000)
L2.ΔE × X		-0.001*	-0.001*		-0.001**
		(0.000)	(0.000)		(0.000)
Net import				0.005	0.006
				(0.023)	(0.022)
ΔE × Net import				0.000	0.000
				(0.000)	(0.000)
L.ΔE × Net import				0.000	0.000
				(0.000)	(0.000)
L2.ΔE × Net import				-0.000*	-0.000*
				(0.000)	(0.000)
Country FE	Y	Y	Y	Y	Y
Cluster	cty	cty	cty	cty	cty
R^2	0.45	0.45	0.45	0.46	0.46
Country-Year	5,871	5,871	5,871	4,671	4,671
Countries	170	170	170	128	128
Countries: AE	35	35	35	34	34
Countries: EM	86	86	86	67	67
Countries: LIC	49	49	49	27	27
Start	1973	1973	1973	1973	1973
End	2022	2022	2022	2022	2022

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Annual regression robust: L3: 7_annual_20230823 08.do

	(1)	(2) RE	(3) LC	(4)	(5) RE
GDP per capita (YC)	2.258	1.434	2.143	2.258	1.517
	(1.184)	(1.335)	(1.207)	(1.190)	(1.312)
Output gap (g)	0.017	0.080*	0.054	0.007	0.064
	(0.037)	(0.038)	(0.037)	(0.036)	(0.039)
Inflation expectation ($\mathbb{E}\pi$)	0.491***	0.478***	0.475***	0.486***	0.477***
	(0.103)	(0.099)	(0.094)	(0.102)	(0.098)
ΔE	0.217***	0.224***	0.241***	0.195***	0.177***
	(0.011)	(0.017)	(0.020)	(0.022)	(0.023)
L.ΔE	0.095***	0.101***	0.120***	0.075***	0.057*
	(0.013)	(0.018)	(0.022)	(0.015)	(0.023)
L2.ΔE	0.010	0.020	0.033*	0.003	0.024*
	(0.009)	(0.011)	(0.015)	(0.008)	(0.011)
X		0.179**	0.161***		0.145*
		(0.054)	(0.039)		(0.056)
$\Delta E \times$ X		-0.000	-0.001		0.001
		(0.000)	(0.000)		(0.001)
L.$\Delta E \times$ X		-0.000	-0.001		0.001
		(0.001)	(0.001)		(0.001)
L2.$\Delta E \times$ X		-0.000	-0.001		-0.001
		(0.000)	(0.000)		(0.000)
Net import				0.011	-0.009
				(0.028)	(0.028)
$\Delta E \times$ Net import				0.000	0.001
				(0.000)	(0.000)
L.$\Delta E \times$ Net import				0.000	0.001*
				(0.000)	(0.000)
L2.$\Delta E \times$ Net import				0.000	-0.000
				(0.000)	(0.000)
Country FE	Y	Y	Y	Y	Y
Cluster	cty	cty	cty	cty	cty
R^2	0.70	0.72	0.72	0.71	0.73
Country-Year	841	788	788	841	788
Countries	36	32	32	36	32
Countries: AE	26	25	25	26	25
Countries: EM	10	7	7	10	7
Countries: LIC	0	0	0	0	0
Start	1997	1997	1997	1997	1997
End	2022	2022	2022	2022	2022

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$