INTERNATIONAL MONETARY FUND

# Greenflation or Greensulation? The Case of Fuel Excise Taxes and Oil Price Pass-through

JaeBin Ahn

WP/24/153



**2024**
JUL

WORKING PAPER

 WP/24/153

**IMF Working Paper**
Western Hemisphere Department

**Greenflation or Greensulation? The Case of Fuel Excise Taxes Oil Price Pass-through**
**Prepared by JaeBin Ahn***

Authorized for distribution by Nigel Chalk
July 2024



**ABSTRACT:** Can a carbon tax reduce inflation volatility? Focusing on fuel excise taxes, this paper provides systematic evidence on their role as a shock absorber that helps mitigating the impact of global oil price shocks on domestic inflation. Exploiting substantial variation in fuel tax rates across 28 OECD countries over the period from 2014 to 2021, a simple idea that a per-unit, specific tax takes up a portion of the product price immune to cost shocks goes a long way toward explaining heterogeneity in the degree of oil price pass-through into domestic inflation across countries. A back-of-the-envelope calculation from the estimation results supports its quantitative significance---differences in fuel tax rates could explain about 30% of the variation in annual headline CPI inflation rates observed between the U.S. and U.K. during the 2021 inflation surge.



| | |
|---|---|
| JEL Classification Numbers: | E31, H23, Q58 |
| Keywords: | Fuel excise tax; gasoline tax; diesel tax; oil price pass-through; retail fuel price; inflation; greenflation; greensulation, |
| Authors' email addresses: | jahn@IMF.org |



* I would like to thank Nigel Chalk, Mai Dao, Romain Duval, Davide Furceri, Thomas Gade, Tibor Hanappi, Kotaro Ishi, Geoffrey Keim, Josef Platzer, Keyra Primus, Gregor Schwerhoff, Frederick Toscani, and participants at the IMF FAD seminar for their helpful comments and discussions. The views expressed here are those of the author and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

# Greenflation or Greensulation? The Case of Fuel Excise Taxes and Oil Price Pass-through*

JaeBin Ahn

July 3, 2024

**Abstract**

Can a carbon tax reduce inflation volatility? Focusing on fuel excise taxes, this paper provides systematic evidence on their role as a shock absorber that helps mitigating the impact of global oil price shocks on domestic inflation. Exploiting substantial variation in fuel tax rates across 28 OECD countries over the period from 2014 to 2021, a simple idea that a per-unit, specific tax takes up a portion of the product price immune to cost shocks goes a long way toward explaining heterogeneity in the degree of oil price pass-through into domestic inflation across countries. A back-of-the-envelope calculation from the estimation results supports its quantitative significance—differences in fuel tax rates could explain about 30% of the variation in annual headline CPI inflation rates observed between the U.S. and U.K. during the 2021 inflation surge.

**Keywords:** Fuel excise tax, gasoline tax, diesel tax, oil price pass-through, retail fuel price, inflation, greenflation, greensulation,

*JaeBin Ahn: International Monetary Fund, Email: jahn@imf.org; I would like to thank Nigel Chalk, Mai Dao, Romain Duval, Davide Furceri, Thomas Gade, Tibor Hanappi, Kotaro Ishi, Geoffrey Keim, Josef Platzer, Keyra Primus, Gregor Schwerhoff, Frederick Toscani, and participants at the IMF FAD seminar for their helpful comments and discussions. The views expressed here are those of the author and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

# 1 Introduction

A carbon tax is regarded as one of the most effective climate change mitigation strategies as it induces a wide range of behavioral responses to cut greenhouse gas emissions—such as reducing energy use and shifting to cleaner energy sources across the power, industry, transport, and building sectors—through higher prices for carbon-intensive fuels and electricity (Black et al., 2022). At the same time, however, it poses a concern on temporary inflationary consequences, constituting a prominent source of potential greenflation (e.g., IMF, 2022; Schnabel, 2022).[1]

A case in point is fuel excise tax.[2] There are good reasons to advocate higher fuel taxes: reducing fuel consumption and greenhouse emissions, thereby facilitating green transition; raising government tax revenue to fund, for instance, clean energy infrastructure; correcting traffic congestion costs and accident costs (Parry et al., 2014). Nonetheless, raising fuel taxes is a political hot button in many advanced economies (Knittel, 2012), as it could stoke inflation immediately while disproportionately hurting low-income households.[3,4]

Against the backdrop, this paper makes yet another case for higher fuel excise taxes, namely, taming inflation volatility. The basic idea stems from the property that fuel excise taxes are, just like any other kind of Pigouvian taxes, set as specific amount per each unit of quantities sold. Since they are not affected by changes in crude oil price, higher fuel taxes naturally imply that a smaller portion of retail fuel prices is affected by crude oil prices than otherwise, thereby dampening the effect of oil price shocks on retail fuel prices.[5] Considering the relative importance of fuel oil items in the Consumer Price Index (CPI), therefore, fuel excise tax may operate as a shock absorber—mitigating the impact of global oil price shocks on headline CPI inflation, and, to a lesser extent, on core CPI inflation.[6]

We take this simple idea to empirical scrutiny by exploring fuel tax rate and retail fuel price datasets that cover both gasoline and diesel for 28 OECD countries over the period of 2014 to

[1] A general discussion about inflationary consequences of high taxation dates at least back to Smith (1952).

[2] Even if their primary objective may not be solely to reduce emissions, fuel excise taxes can be seen as implicit carbon taxes (IMF and OECD, 2021), not least because one of the most straightforward ways to administer carbon taxes is piggybacking on existing fuel excise taxes (Parry, 2019).

[3] Raising the fuel tax is expected to result in a one-time increase in retail price inflation, given estimates that suggest nearly full pass-through of the fuel tax to retail prices (e.g., Tsvetanov, 2024)

[4] In fact, distributional implications of higher fuel taxes are not unambiguous (Sterner, 2012). Fuel taxes tend to be more progressive in developing economies where the poorest households do not own cars, which has been one of the main arguments for fuel subsidy reforms (Del Granado et al., 2012). By contrast, fuel taxes are generally thought to be regressive in advanced economies, placing a greater burden on the poorest households since fuel consumption is relatively constant across the income distribution (Knittel and Sandler, 2018). This burden could potentially be offset by using the tax revenue to address distributional consequences (Klenert et al., 2018).

[5] This is in stark contrast to ad valorem taxes that would play no differential role in transmission of price shocks.

[6] While reducing the weight of fuel products in the CPI basket through effective consumption discouragement could potentially lessen the impact of fuel price changes on overall inflation, this aspect falls beyond the scope of the paper. See Millischer et al. (2024) for related discussion.

2021. Substantial variation in fuel tax rates across countries, which turns out to explain most of cross-country variation in retail fuel prices, provides an ideal setting for empirical investigation into the quantitative significance of the role played by fuel excise taxes in determining the degree of crude oil price pass-through.

Our main findings on oil price pass-through to retail fuel prices are summarized as follows. Country-by-country estimation results from simple OLS as well as ARDL-ECM estimator confirm that there is a strong negative relationship between fuel tax rates and estimated degrees of oil price pass-through, suggesting that retail fuel prices are indeed more sensitive to crude oil price changes in countries with lower fuel tax rates. According to panel data regressions with an interaction term between fuel tax rate and crude oil price, the pass-through rate is expected to decline by more than half from 50% to 20% when a country raises fuel tax rates from zero to one dollar per liter. Moreover, impulse responses by local projections show that the response of monthly retail fuel price inflation to a one percentage point change in the global crude oil price is about 0.2 percentage point smaller in each of the first two months in countries with fuel tax rates close to one dollar per liter than in countries with fuel tax rates close to zero. Meanwhile, the pass-through to retail fuel price inflation is estimated to die out within two months after the global oil price shock. [7]

We further show that such differential effects are transmitted to headline and core CPI inflation. Simple OLS and ARDL-ECM estimators continue to find a strong negative relationship between fuel tax rates and pass-through estimates to CPI inflation, while panel data regressions with an interaction term predicts that the pass-through rate to headline and core CPI would reduce drastically from 2.8% to 0.5% and, to a lesser extent, from 0.8% to 0%, respectively, when the average fuel tax rate increases from zero to one dollar per liter. In addition, local projections estimate that the response of monthly CPI inflation to a one percentage point change in the global crude oil price in countries with fuel tax rates close to one dollar per liter is about 0.02 and 0.01 percentage point smaller in the first two months, respectively for headline and core, compared to countries with fuel tax rates close to zero. The pass-through to month-over-month CPI inflation also tends to be completed within two months after the global oil price shock.

Overall, the estimation results support the quantitatively significant role of fuel excise taxes in dampening inflation volatility due to oil price shocks. Taking the onset of the recent worldwide inflation surge in 2021—accompanied by a 50% hike in annual average crude oil price—as an illustrative example, a simple back-of-the-envelope calculation suggests that the lower fuel tax rate in the U.S. (13 cents per liter) relative to the U.K. (80 cents per liter) could account for about

[7] While a proactive government policy response to oil price shocks, such as temporarily reducing fuel tax rates to shield households and businesses from oil price hikes, could also potentially explain the observed pattern, our analysis confirms that such policies were not widely implemented across countries during the sample period.

30% of the difference in annual headline CPI inflation rates observed in the U.S. (4.7%) and U.K. (2.5%) in 2021.[8]

**Related literature** Given the major role of crude oil price shock as a driver of global inflation (Ha et al., 2023b), estimating the oil price pass-through has been one of the key steps to understanding inflation dynamics. Kilian and Zhou (2022) find that although the short-run effects of gasoline price shocks on headline inflation are sizable, they have limited effects on long-run household inflation expectations, the degree of which may vary across countries (Kilian and Zhou, 2023). Aastveit et al. (2023) find that the inflation pass-through of oil price shocks depends on the underlying drivers in the global market for crude oil via an inflation expectation channel. By contrast, Conflitti and Luciani (2019) report that oil price fluctuations have a limited but long lasting effect on core inflation in the U.S. and the euro area. Alp et al. (2023) also document that increases in oil prices lead to small but significant second-round effects on inflation with long lags in advanced economies. Chen (2009) report that a declining trend in the oil price pass-through into inflation across 19 advanced economies can be attributed to the appreciation of the domestic currency, a more active monetary policy in response to inflation, and a higher degree of trade openness.[9] Choi et al. (2018) explore a monthly panel of 71 advanced and developing economies over the period from 2000 to 2015 to find that the share of transport in the CPI basket and energy subsidies are the most robust factors in explaining cross-country variations in the effects of oil price shocks. Baba and Lee (2022) identify labor market institutions as the main determinant of the extent to which oil price shocks are passed onto wages. Kpodar and Abdallah (2017) employ a monthly panel of 162 countries over the period from 2000 to 2014 to find a substantial level of heterogeneity in the degree of oil price pass-through to retail fuel prices across income groups and regions, likely reflecting the presence of fuel subsidies and price controls in some oil exporting countries. Kpodar and Imam (2021) further focus on 109 developing countries over the same period to uncover the pricing mechanism and exchange rates as the key factors impacting the degree of oil price pass-through to retail fuel prices.[10] Gautier et al. (2023) investigate how gasoline retail prices in France respond to the wholesale gasoline price quoted on the Rotterdam market by exploring several millions of daily station-level prices collected over the period 2007-2018. Yilmazkuday (2021) estimates oil price pass-through into consumer prices and gasoline retail prices using weekly US gasoline and consumer prices data.

[8]Decomposing the sources of inflation based on the estimated model for 11 advanced economies, Blanchard and Bernanke (2023) document that energy price shocks account for much of the rise of overall inflation in late 2021.

[9]Sekine and Tsuruga (2018) consider a broader commodity price shocks beyond oil prices and find that the effect of commodity price shocks on inflation is transitory particularly in countries with a flexible exchange rate regime.

[10]Kpodar and Liu (2022) employ the extended coverage of the same dataset to study the distributional implications of the oil price pass-through.

Most recently, Vlieghe (2024) evaluates the extent to which cross-country variation in energy price inflation explains the cross-country variation in post-pandemic core inflation. The current paper contributes to this vast literature on oil price pass-through by providing, to our knowledge, the first systematic cross-country evidence on a role of fuel excise taxes in determining the degree of oil price pass-through to domestic prices.

This paper also adds to an emerging literature that studies the effect of carbon taxation on inflation. Empirical studies include Konradt and Weder di Mauro (2023) for Canada and European countries; Konradt et al. (2024) for the Euro Area countries; Moessner (2022) for OECD countries. Del Negro et al. (2023) develop a multi-sector New Keynesian model to find a potentially sizeable but short-lived inflation-output tradeoff from an increase in carbon taxes. Regarding the effect on inflation volatility, Santabárbara and Suárez-Varela (2022) find evidence from OECD counries that cap-and-trade schemes are associated with larger volatility in CPI headline inflation, but no significant effect is found in the case of carbon taxes. Unlike previous studies in the literature, this paper focuses on a potential role of fuel excise taxes in reducing inflation volatility by insulating retail fuel prices from crude oil price fluctuation.

The rest of the paper is structured as follows. Section 2 provides the conceptual background on the potential role of fuel excise taxes in insulating domestic inflation from crude oil price fluctuation. In Section 3, we introduce our data sources and document stylized facts that motivate us to investigating the mechanism. Section 4 describes our empirical approach and reports estimation results. Section 5 concludes.

## 2 Conceptual Background

We set after-tax retail fuel price in USD per liter in country $c$ in time $t$, $P_{A,ct}$, as:

$$P_{A,ct} = (1 + V_{ct}) \times (P_{B,ct} + T_{ct}), \tag{1}$$

where $P_{B,ct}$ denotes before-tax fuel price in USD per liter in country $c$ in time $t$. $T_{ct}$ and $V_{ct}$ denote motor fuel tax in USD per liter and ad-valorem tax—value-added tax (VAT) or goods and service tax (GST)—in country $c$ in time $t$, respectively. Motor fuel taxes in most countries are, just like other types of excise taxes, levied at a specific rate per unit. On top of them, value-added tax or sales tax is applied as an ad valorem tax.

Before-tax fuel price, $P_{B,ct}$, is in turn expressed as a function of two factors, $P_{O,t}$ and $C_{ct}$:

$$P_{B,ct} = F(P_{O,t}, C_{ct}), \tag{2}$$

where $P_{O,t}$ is global crude oil price in USD and $C_{ct}$ encompasses a set of other factors than crude oil price that affect before-tax fuel price—e.g., markups, refinery and distribution costs, etc.—which may vary across countries as well as over time.

Taking log on both sides, equation (1) becomes:

$$\ln P_{A,ct} = \ln (1 + V_{ct}) + \ln (P_{B,ct} + T_{ct}), \tag{3}$$

and the degree of global oil price pass-through to retail fuel price in USD, which is defined as the elasticity of after-tax fuel price in USD with respect to global oil price, can be derived by applying the chain rule:

$$\beta_{A,ct} \equiv \frac{d \ln P_{A,ct}}{d \ln P_{O,t}} = \beta_{B,ct} \frac{P_{B,ct}}{P_{B,ct} + T_{ct}}, \tag{4}$$

where $\beta_{B,ct}$ denotes the degree of global oil price pass-through to before-tax fuel price in USD, similarly defined as the elasticity of before-tax fuel price with respect to global oil price. In principle, the presence of variable markups or distributional costs is expected to lead to incomplete pass-through of crude oil prices to before-tax fuel prices (i.e., $\beta_{B,ct} \equiv \frac{d \ln P_{B,ct}}{d \ln P_{O,t}} < 1 = 100\%$), the degree of which may vary across countries. Assuming that it is not affected by fuel tax rate (i.e., $\frac{d\beta_{B,ct}}{dT_{ct}} = 0$), we can conclude that the pass-through rate to after-tax retail fuel price is decreasing in fuel tax rate:

$$\frac{d\beta_{A,ct}}{dT_{ct}} < 0 \tag{5}$$

Intuitively, the effect of oil price shocks on retail fuel prices is dampened by higher fuel tax rates as they lead to a smaller portion of retail fuel prices being affected by crude oil prices.

**Claim 1** *The degree of global oil price pass-through to retail fuel prices in USD will be higher in countries where the fuel tax rate is lower, and lower in countries where the fuel tax rate is higher.*

Moreover, considering that headline CPI inflation is essentially a weighted sum of each basket's price inflation in local currency unit (i.e., $\Delta \ln P_{i,ct}^{LCU}$) with respective weights, $0 < w_i < 1$:

$$\pi_{ct}^{HCPI} \equiv \Delta \ln HCPI_{ct} = \sum\nolimits_i w_{i,ct} \Delta \ln P_{i,ct}^{LCU}, \tag{6}$$

the degree of global oil price pass-through to headline CPI will be determined by the *direct* effect via retail fuel prices ($w_{A,ct}\beta_{A,ct}^{LCU}$) and *second-round* effects via all other consumer prices ($\sum\nolimits_{i \neq A} w_{i,ct}\beta_{i,ct}^{LCU}$):

$$\beta_{ct}^{HCPI} \equiv \frac{d\pi_{ct}^{HCPI}}{d\ln P_{O,t}} = w_{A,ct}\beta_{A,ct}^{LCU} + \sum\nolimits_{i \neq A} w_{i,ct}\beta_{i,ct}^{LCU}, \tag{7}$$

where $\beta_{i,ct}^{LCU}$ denotes the pass-through rate of global oil price to $i$ goods price in local currency unit (LCU), taking into account the concurrent exchange change rate pass-through.

As long as the direct effect dominates second-round effects, it suggests that the pass-through rate to headline CPI would mostly reflect the pass-through rate to retail fuel price in LCU multiplied by the motor fuel weight in the CPI basket. By contrast, the pass-through to core CPI would reflect, by construction, second-round effects only.

**Claim 2** *The degree of global oil price pass-through to headline CPI is expected to be largely proportional to the pass-through to retail fuel prices in LCU, with the ratio determined by the motor fuel weight in the CPI basket.*

# 3 Data and Stylized Facts

## 3.1 Data

Our dataset mainly consists of three different types of data: motor fuel tax rates, retail fuel prices, and CPI inflation. We focus on the period from 2014 to 2021 because our retail fuel price data begins in 2014, while several European countries introduced various energy price support schemes in 2022 amid the energy crisis triggered by Russian invasion of Ukraine.[11] The sample includes 28 OECD countries for which retail fuel price data are available and which did not implement any fuel subsidy programs during the sample period.[12]

**Motor fuel tax rates** Gasoline tax and diesel tax rate data are obtained from IEA Energy Prices that compiles information on the energy taxes in OECD countries, with details on the end-use taxation breakdown into VAT/GST and excise taxes that include, for example, environmental taxes, carbon taxes, renewable support taxes, energy security taxes, social taxes, and other taxes.[13]

[11] Sgaravatti et al. (2023) summarize various kinds of fiscal responses—e.g., transfers, energy subsidies, and tax cuts—implemented to contain the increase in the price of energy for households and businesses. Dao et al. (2023) assess that the energy price measures contributed to containing euro area headline inflation in 2022 by about 2 percentage points, while Erceg et al. (2024) demonstrate that the conditions under which energy subsidies reduce core inflation is quite restrictive. Ari et al. (2022) discuss related policy recommendations.

[12] According to IEA's Fossil Fuel Subsidies Database, Colombia and Mexico had oil subsidy programs. The resulting list of 28 OECD sample countries is: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Latvia, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States of America.

[13] Environmental taxes comprise all taxes and levies applicable with an environmental purpose, including carbon-related taxes, soil remediation tax, sulphur tax, NO tax and CO2 tax. In particular, carbon taxes are applied with the purpose of reducing and/or compensating the emission of greenhouse gas emissions. Renewable support taxes

This database has been featured in IEA's annual report entitled as "Energy Prices and Taxes for OECD Countries". We take excise taxes on gasoline and diesel from the database, measured in USD per liter and averaged over the sample period for each sample country.

**Retail fuel prices** Global retail fuel prices data come from GlobalPetrolPrices.com that provides weekly or monthly retail gasoline and diesel price data in 135 countries, starting in March 2014. The database collects the final retail fuel prices—paid by households and industry including all taxes and fees, and measured in both local currency and USD per liter—from at least three independent reliable sources in each country, including the Ministries of Energy, Transport, or Commerce; fuel price transparency mechanisms; local automobile associations; consumer advocacy groups; international fuel companies; local petroleum monopolies; multilateral organizations; and the local media.[14]

**CPI inflation** Monthly headline and core CPI inflation data are taken from Ha et al. (2023a), which are publicly available at the World Bank website. This is a global inflation database that contains a wide range of inflation measures (headline, food, energy, and core consumer price inflation; producer price inflation; and gross domestic product deflator changes) at multiple frequencies (monthly, quarterly and annual) for an extended period (1970–2023) and a large number (up to 209) of countries.[15]. In addition, country-level information on average weight of motor fuel consumption in CPI basket and other monthly indicators are taken from the OECD Database, while monthly crude oil price data come from the IMF's commodity price database.

## 3.2 Stylized Facts

Figure 1 describes cross-country difference in average gasoline and diesel tax rates, expressed in USD per liter. Several interesting observations stand out. First, there is a strong positive correlation between them, implying that a country that imposes a higher (lower) tax rate on gasoline tends to

comprise all taxes and levies applied with the aim of supporting the investment in renewable energy technologies. Energy security taxes comprise all taxes and levies applied with the purpose of guaranteeing supply security. Social taxes comprise all taxes and levies applied to energy products whose revenue is used to support social policies such as financing the education system, etc. Other taxes comprise all other types of excise taxes than listed above. More details on fuel tax rate data collection methodology can be found at https://www.iea.org/data-and-statistics/data-product/energy-prices#documentation

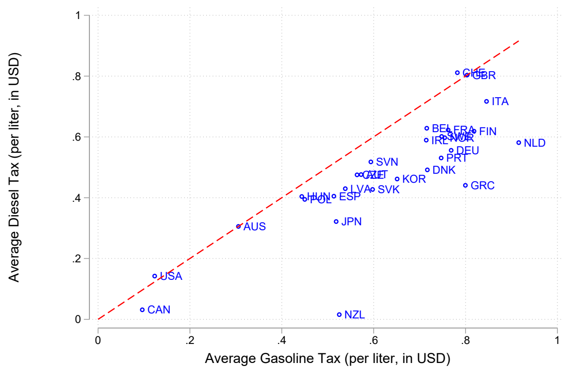
[14] More details on retail fuel price data collection methods can be found at https://www.globalpetrolprices.com/data/

[15] Original data sources for this database include ILO's ILOSTAT, IMF's International Financial Statistics, Consumer Price Index, and World Economic Outlook databases, World Bank's World Development Indicators (WDI), OECD.Stat, Eurostat, Federal Reserve Economic Data (FRED), UNdata, as well as a large number of country-specific sources, including central banks and statistical offices.

impose a higher (lower) tax rate on diesel as well.[16] Second, most countries are located below the red dashed 45 degree line, revealing that they mostly impose higher tax rates on gasoline than on diesel. Third, and most importantly in our context, there is substantial heterogeneity in fuel tax rates across countries from close to 0 to nearly one dollar per liter, generating an important source of variation for empirical identification.

**Fact 1** *There is substantial variation in fuel tax rates across countries. Gasoline and diesel tax rates are highly correlated, with gasoline tax rates typically being higher than diesel tax rates.*

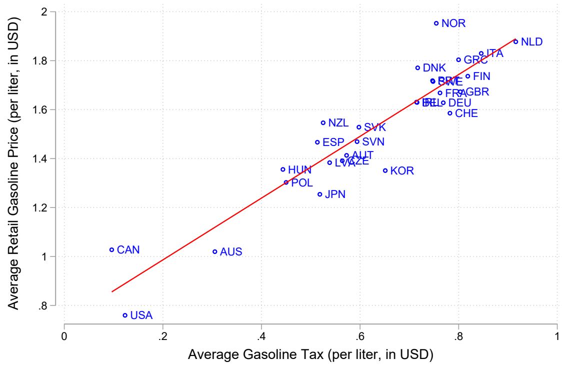
Figure 1: Gasoline and Diesel Tax Rates across Countries



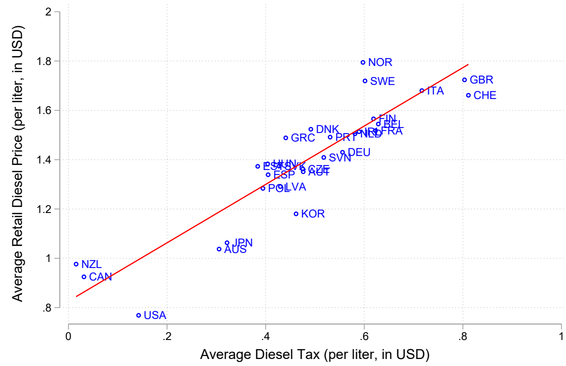

Notes: This figure plots gasoline (x-axis) and diesel (y-axis) tax rates across countries. They are both expressed in USD per liter, averaged over the period 2014-2021. The red dashed line corresponds to the 45 degree line.

[16]In New Zealand, there is no tax on diesel; instead, diesel vehicles have to pay road user charges (RUC) according to how many kilometres a vehicle travels.

Figure 2: Retail Fuel Prices and Fuel Tax Rates




(a) Retail Prices and Tax Rates: Gasoline




(b) Retail Prices and Tax Rates: Diesel

Notes: This figure plots fuel tax rates (x-axis) and retail fuel prices (y-axis) across countries. Panels (a) and (b) are for gasoline and diesel, respectively. They are all expressed in USD per liter, averaged over the period 2014-2021. The OLS fitted line is drawn in red.

Figure 2 illustrates the extent to which variation in fuel tax rates can account for cross-country difference in per liter USD retail fuel prices. A strong positive correlation confirms that cross-country variation in per liter USD retail fuel prices is mostly explained by fuel tax rates for both gasoline (2a) and diesel (2b).[17] Moreover, fuel tax rates tend to account for a large portion of retail fuel price levels by, on average, around 40 percent for gasoline and 33 percent for diesel.

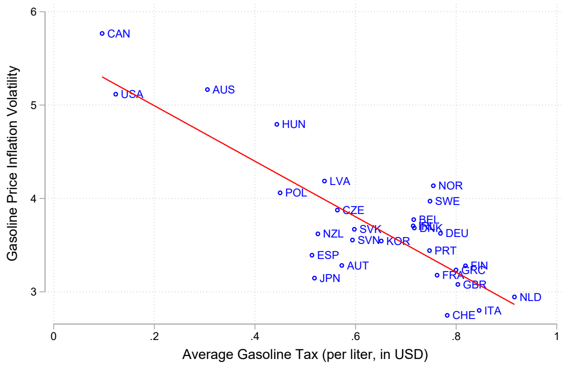
**Fact 2** *Cross-country variation in retail fuel prices is primarily explained by differences in fuel tax rates across countries*

Figure 3 illustrates the potential impact of fuel tax rates on inflation stability. Specifically, we plot month-over-month retail fuel price inflation volatility during the sample period on the y-axis, separately for gasoline (3a) and diesel (3b), which show a strong negative correlation with fuel tax rates on the x-axis. This is consistent with the prediction from Claim 1 in that higher fuel tax rates would act as an oil price shock absorber, leading to lower pass-through to retail fuel prices and thus possibly to lower retail fuel price inflation volatility.

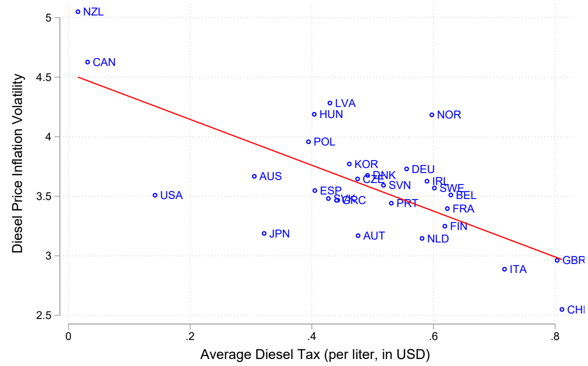
**Fact 3** *There is a strong negative relationship between retail fuel price inflation volatility and fuel tax rates across countries.*

[17] Fuel Price Primer by GlobalPetrolPrices.com also notes that most of the difference in retail fuel prices across countries can be attributed to the difference in the level of excise taxes.

Figure 3: Retail Fuel Price Inflation Volatility and Fuel Tax Rates




(a) Inflation Volatility and Tax Rates: Gasoline



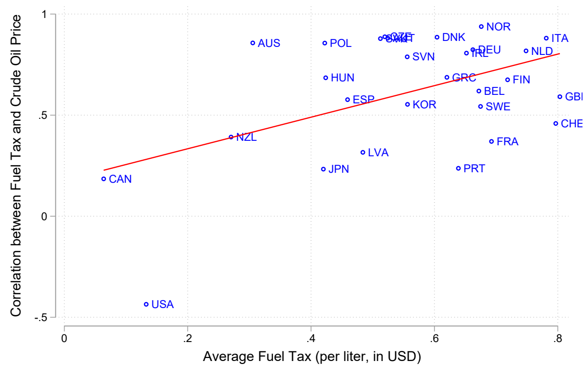

(b) Inflation Volatility and Tax Rates: Diesel

Notes: This figure plots country-level average fuel tax rates (x-axis) and month-over-month retail fuel price inflation volatility (y-axis) over the period 2014-2021. Panels (a) and (b) are for gasoline and diesel, respectively. Fuel tax rates are expressed in USD per liter. The OLS fitted line is drawn in red.

However, this could be a simple reflection of proactive policy responses to oil price shocks. When oil price hikes, the government may consider temporarily reducing fuel tax rates to shield households and businesses from oil price shocks. To the extent that such an incentive is greater in countries with higher fuel tax rates, fuel price inflation might well be more stable in these countries than in countries with lower fuel tax rates. If this were indeed the case, we should observe a negative correlation between fuel tax rates and crude oil price in each of those countries, the degree of which in turn should be particularly stronger in countries with higher fuel tax rates.

To check this possibility, Figure 4 plots country-level average fuel tax rate expressed in USD per liter on the x-axis and within-country correlation between fuel tax rate and crude oil price on the y-axis. First, within-country correlation between fuel tax rate and crude oil price turns out to be positive for most countries, suggesting that proactive policies to adjust fuel tax rates in response to oil price shocks were not prevalent during the sample period. Further, there is a positive relationship between within-country correlation level and average fuel tax rates, confirming that Fact 3 cannot be simply explained by the government policy to mitigate adverse effects of oil price shocks.

Figure 4: Correlation between Fuel Tax Rates and Crude Oil Price across Countries




Notes: This figure plots country-level average fuel tax rate expressed in USD per liter(x-axis) and within-country correlation between fuel tax rate and crude oil price over the sample period (y-axis). The OLS fitted line is drawn in red.

**Fact 4** *Within countries, the correlation between crude oil prices and fuel tax rates is positive for most countries. Moreover, across countries, the relationship between the correlation level and average fuel tax rate, if any, is positive. This indicates that proactive policies to adjust fuel tax rates in response to oil price shocks were not prevalent during the sample period.*

# 4 Empirical Analysis

## 4.1 Retail Fuel Price Inflation

**Pass-through Estimates** We begin by estimating the standard pass-through regression below for each country individually:

$$\Delta \ln P_{A,t} = c + \sum\nolimits_{i=0}^{n} \beta_i \Delta \ln P_{O,t-i} + \epsilon_t \tag{8}$$

and calculate the country-specific degree of global oil price pass-through to retail fuel prices as the sum of the estimated coefficients, $\sum_{i=0}^{n} \widehat{\beta}_i$, *a la* Campa and Goldberg (2005) and Nakamura and Zerom (2010) among others. The dependent variable is either gasoline or diesel retail price inflation such that the pass-through estimate is also fuel type specific. Both retail fuel price and crude oil price inflation variables are measured as monthly (i.e., month-over-month) changes in log USD unit prices.

To ensure the robustness of estimation results to alternative estimators, we also consider the

ARDL-ECM approach, which has been frequently employed in the literature to estimate the degree of pass-through and address possible cointegrating relationships among the variables of interest (e.g., Ahn et al., 2017;Ahn and Lee, 2023):

$$\Delta \ln P_{A,t} = c + \alpha \left(\ln P_{A,t-1} - \beta \ln P_{O,t-1}\right) + \delta \Delta \ln P_{A,t-1} + \sum_{i=0}^{n} \gamma_i \Delta \ln P_{O,t-i} + \varepsilon_t, \qquad (9)$$

where $\sum_{i=0}^{n} \widehat{\gamma}_i$ corresponds to the short-run pass-through rate. For both estimators, we set $n$ as 2 since the effect of global oil price changes on monthly retail fuel price inflation tends to last two months.

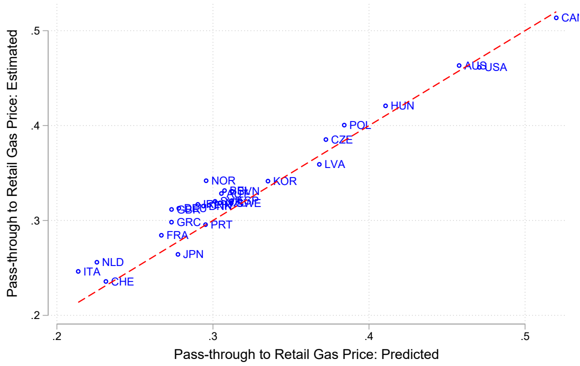
First, we check the validity of our estimation strategy by comparing the estimated pass-through rate to after-tax fuel prices from equation (8) or (9) with predicted pass-through rate calculated from equation (4) in a following way:

$$\widehat{\widehat{\beta}}_{A,c} = \widehat{\beta}_{B,c} \overline{\frac{P_{B,ct}}{P_{B,ct} + T_{ct}}},$$

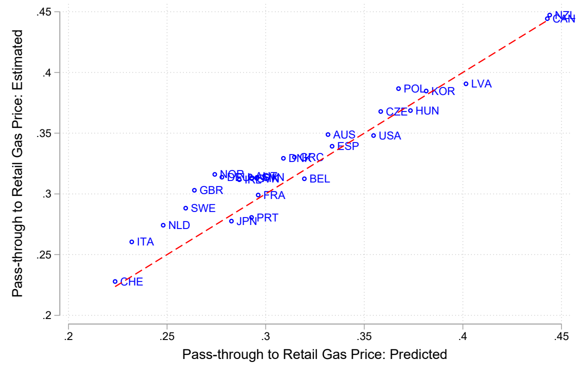
where the country-level estimated pass-through rate to before-tax fuel price ($\widehat{\beta}_{B,c}$) is obtained from regressions in equation (8) or (9) with before-tax fuel price as the dependent variable. Since before-tax fuel prices are not directly observable, we back them out from equation (1). The second term on the right hand side is taken as country-level average value over the sample period. The idea here is that an unbiased estimator should yield estimated pass-through rates as close as to the predicted values.

Figure 5 plots the comparison between predicted and estimated pass-through rates to after-tax fuel prices in USD from both specifications in (8) and (9). Left panels (5a, 5c) are for pass-through to gasoline prices, while right panels (5b, 5d) are for pass-through to diesel prices. The pass-through estimates in top panels (5a, 5b) and bottom panels (5c, 5d) are from OLS and ARDL-ECM estimator, respectively. In each panel, country-level predicted (x-axis) and estimated (y-axis) pass-through rates closely align along the 45 degree line, confirming that our pass-through estimates are unlikely to be biased and are therefore highly reliable.

Figure 5: Crude Oil Price Pass-through to Retail Fuel Prices in USD: Predicted vs. Estimated

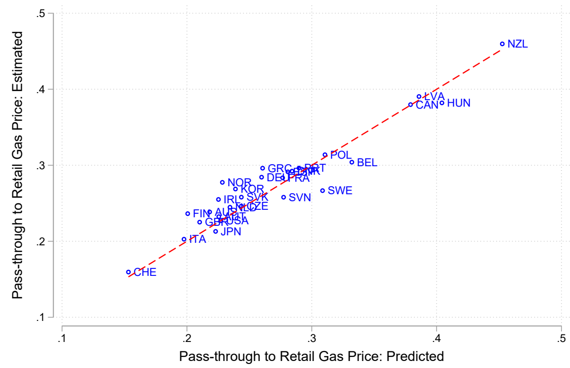



(a) Pass-through Estimates: Gasoline (OLS)




(b) Pass-through Estimates: Diesel (OLS)


(c) Pass-through Estimates: Gasoline (ECM)



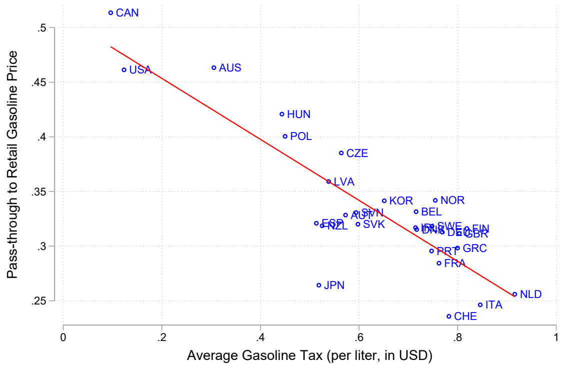

(d) Pass-through Estimates: Diesel (ECM)

Notes: This figure plots country-level predicted (x-axis) and the estimated (y-axis) degree of crude oil price pass-through to retail fuel prices in USD. Left panels are for gasoline and right panels are for diesel. The pass-through estimates in top panels and bottom panels are from simple OLS and ECM estimator, respectively. The red dashed line corresponds to the 45 degree line. The sample covers the period 2014-2021.

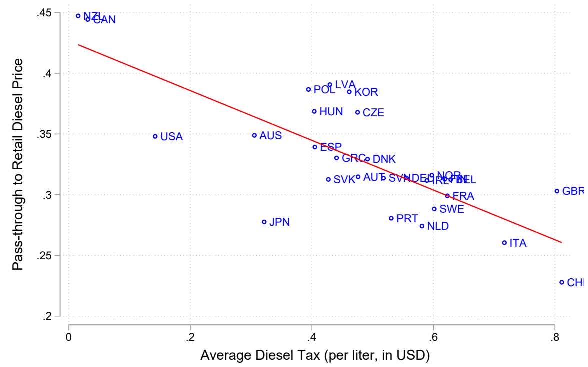
Figure 6 relates the estimated pass-through rates from both specifications in (8) and (9) to fuel tax rates. Left panels (6a, 6c) are for gasoline, while right panels (6b, 6d) are for diesel. The pass-through estimates in top panels (6a, 6b) and bottom panels (6c, 6d) are from OLS and ARDL-ECM estimator, respectively. In each panel, country-level average fuel tax rates are shown on the x-axis and the estimated degree of oil price pass-through to retail fuel prices in USD are drawn on the y-axis.

In all panels, there is a strong negative relationship between fuel tax rates and pass-through estimates, illustrated by most countries clustering around a steep OLS fitted line in red. This suggests that the oil price pass-through to retail USD fuel prices tends to be higher in countries with low fuel tax rates for both gasoline and diesel, which is robust to estimating models. This is precisely the point predicted by equation (5) and stated in Claim 1.

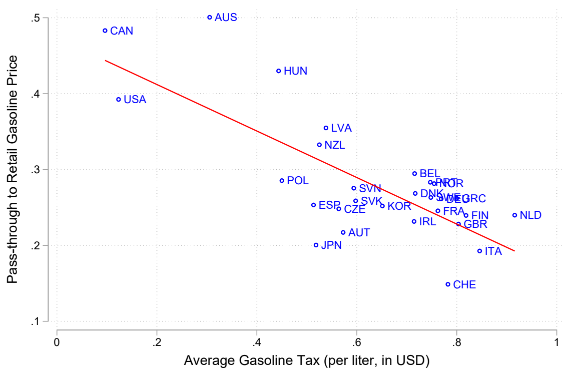
Figure 6: Crude Oil Price Pass-through to Retail Fuel Prices in USD and Tax Rates



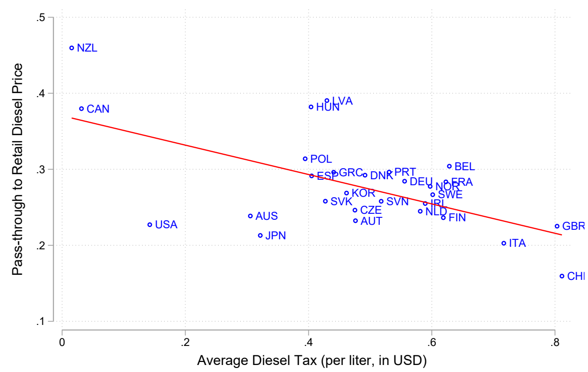

(a) Pass-through and Tax Rates: Gasoline (OLS)




(b) Pass-through and Tax Rates: Diesel (OLS)




(c) Pass-through and Tax Rates: Gasoline (ECM)

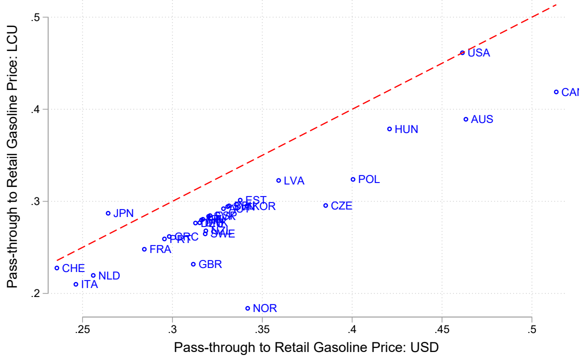



(d) Pass-through and Tax Rates: Diesel (ECM)

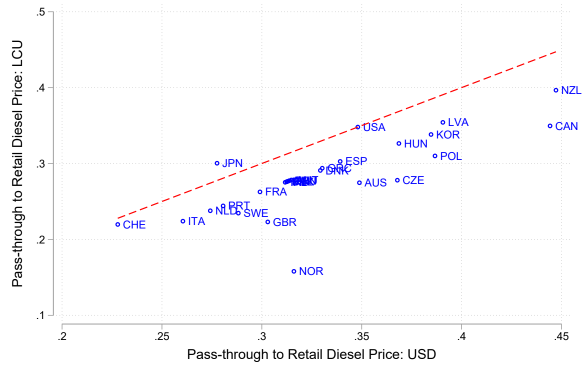
Notes: This figure plots country-level average fuel tax rates (x-axis) and the estimated degree of crude oil price pass-through to retail fuel prices in USD (y-axis). Left panels are for gasoline and right panels are for diesel. The pass-through estimates in top panels and bottom panels are from simple OLS and ECM estimator, respectively. The OLS fitted line is drawn in red. The sample covers the period 2014-2021.

While estimating the global oil price pass-through to USD retail prices is useful for a cross-country comparisons of the role played by fuel taxes, what ultimately matters for domestic inflation is the pass-through to LCU retail prices, which includes accompanying exchange rate changes. As such, we repeat estimation processes above by replacing the dependent variable in equations (8) and (9) with LCU retail prices. Figure 7 summarizes the estimation results on the degree of global oil price pass-through to LCU retail fuel prices, alongside the estimated degree of pass-through to USD retail fuel prices.

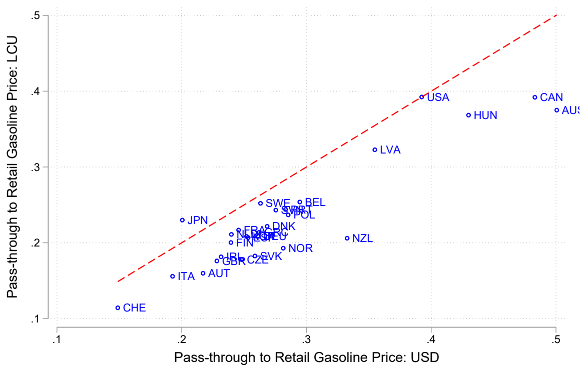
Figure 7: Crude Oil Price Pass-through to Retail Fuel Prices in USD and LCU



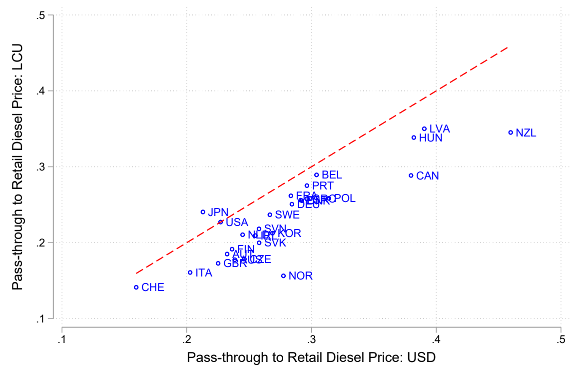

(a) Pass-through to USD and LCU prices: Gasoline (OLS)




(b) Pass-through to USD and LCU prices: Diesel (OLS)




(c) Pass-through to USD and LCU prices: Gasoline (ECM)




(d) Pass-through to USD and LCU prices: Diesel (ECM)

Notes: This figure plots the estimated degree of crude oil price pass-through to retail fuel prices in USD (x-axis) and in LCU (y-axis). Left panels are for gasoline and right panels are for diesel. The pass-through estimates in top panels and bottom panels are from simple OLS and ECM estimator, respectively. The red dashed line corresponds to the 45 degree line. The sample covers the period 2014-2021.

As before, left panels (7a, 7c) and right panels (7b, 7d) correspond to estimation results on pass-through to gasoline and diesel prices, respectively. Likewise, the pass-through estimates in top panels (7a, 7b) and bottom panels (7c, 7d) are from OLS and ARDL-ECM estimator, respectively. In each panel, the estimated degree of oil price pass-through to USD retail fuel prices are shown on the x-axis, while the estimated degree of oil price pass-through to LCU retail fuel prices are drawn on the y-axis.

A couple of observations stand out. First, there is a strong positive relationship between pass-through rates to USD and LCU retail fuel prices, confirming that the degree of global oil price pass-through to LCU retail fuel prices is also largely determined by fuel tax rates. Second, all the countries in the sample, except for Japan, are positioned below the red dashed 45 degree line, indicating that the pass-through rates to retail fuel prices in LCU are lower than those to USD prices. This reflects that the USD strengthened (weakened) as global oil prices declined (increased) in the 2010s (e.g., Obstfeld and Zhou, 2023; IMF, 2023), thereby partly offsetting global oil price shocks when converted to LCU.

To better quantify the role of fuel tax rates in determining the degree of oil price pass-through to retail fuel prices, we modify equation (8) to run a panel regression with interaction terms between global crude oil prices and country-level average motor fuel tax rates:

$$\Delta \ln P_{A,ct} = \sum_{i=0}^{n} [\beta_i \Delta \ln P_{O,t-i} + \gamma_i \Delta \ln P_{O,t-i} \times FuelTax_c] + \varphi_c + \epsilon_{ct}, \tag{10}$$

where the subscript $c$ is added to denote each country in a panel data setting and $\varphi_c$ denotes country fixed effects that capture country-specific characteristics. In this specification, the degree of oil price pass-through to retail fuel prices in a country with zero fuel tax rates is defined as the sum of the coefficients $\sum_{i=0}^{n} \widehat{\beta}_i$, while that in a country with fuel tax rates of one dollar per liter is calculated as the sum of the coefficients $\sum_{i=0}^{n} \left[\widehat{\beta}_i + \widehat{\gamma}_i\right]$.

Estimation results are summarized in Table (1) with $n$ set as 2 and standard errors clustered at the country level. The dependent variable is monthly gasoline retail price inflation in USD (columns (1)-(2)), monthly diesel retail price inflation in USD (columns (3)-(4)), monthly gasoline retail price inflation in LCU (columns (5)-(6)), or monthly diesel retail price inflation in LCU (columns (7)-(8)). Columns (1), (3), (5), and (7) do not include interaction terms, while columns (2), (4), (6), and (8) include interaction terms.

According to column (1), the average pass-through rate of global oil price to gasoline retail price in USD is estimated to be around 34% ($\approx (0.166 + 0.156 + 0.015) \times 100$). However, column (2) reveals substantial heterogeneity in the pass-through rate across countries as suggested by statistically significant coefficient estimates on interaction terms. For countries with gasoline tax rates close to zero, the pass-through rate is estimated to be as high as 50% ($\approx (0.264 + 0.241) \times 100$), whereas for countries with gasoline tax rates close to one dollar per liter it is estimated to be as low as 20% ($\approx (0.264 - 0.161 + 0.241 - 0.140) \times 100$). Likewise, the pass-through rate of oil prices to diesel retail price in USD in a country with diesel tax rates close to zero is estimated to be around 40% ($\approx (0.195 + 0.208) \times 100$) while that in a country with diesel tax rates close to one dollar per liter is estimated to be around 27% ($\approx (0.195 + 0.208 - 0.130) \times 100$). For both gasoline and diesel, columns (5)-(8) confirm that qualitatively identical results to those in columns (1)-(4) hold, but the pass-through rates to LCU retail prices tend to be smaller than those to USD retail prices, consistent with country-level estimation results summarized in Figure (7).

Table 1: Estimation Results: Crude Oil Price Pass-through to Retail Fuel Prices and Tax Rates

| | USD | | | | LCU | | | |
|---|---|---|---|---|---|---|---|---|
| | Gasoline | | Diesel | | Gasoline | | Diesel | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Crude Oil Price Growth | 0.165*** | 0.269*** | 0.159*** | 0.197*** | 0.133*** | 0.219*** | 0.127*** | 0.155*** |
| | (0.014) | (0.050) | (0.012) | (0.038) | (0.012) | (0.037) | (0.011) | (0.038) |
| Crude Oil Price Growth | | -0.167** | | -0.078 | | -0.139** | | -0.059 |
| X Average Tax Rate | | (0.075) | | (0.071) | | (0.054) | | (0.068) |
| 1-Month Lag Crude Oil Price Growth | 0.157*** | 0.250*** | 0.148*** | 0.212*** | 0.141*** | 0.235*** | 0.132*** | 0.191*** |
| | (0.011) | (0.041) | (0.010) | (0.021) | (0.011) | (0.041) | (0.010) | (0.025) |
| 1-Month Lag Crude Oil Price Growth | | -0.150** | | -0.135*** | | -0.152** | | -0.124** |
| X Average Tax Rate | | (0.058) | | (0.039) | | (0.058) | | (0.047) |
| 2-Month Lag Crude Oil Price Growth | 0.014** | -0.009 | 0.022*** | 0.018 | 0.016*** | 0.005 | 0.024*** | 0.034*** |
| | (0.006) | (0.015) | (0.004) | (0.014) | (0.005) | (0.013) | (0.004) | (0.011) |
| 2-Month Lag Crude Oil Price Growth | | 0.038* | | 0.009 | | 0.018 | | -0.020 |
| X Average Tax Rate | | (0.022) | | (0.025) | | (0.019) | | (0.019) |
| Observations | 2,624 | 2,624 | 2,624 | 2,624 | 2,624 | 2,624 | 2,624 | 2,624 |
| R-squared | 0.600 | 0.622 | 0.603 | 0.613 | 0.620 | 0.646 | 0.604 | 0.616 |

Notes: This table summarizes estimation results from equation 10. The dependent variable is monthly gasoline retail price inflation in USD (columns (1)-(2)), monthly diesel retail price inflation in USD (columns (3)-(4)), monthly gasoline retail price inflation in LCU (columns (5)-(6)), or monthly diesel retail price inflation in LCU (columns (7)-(8)). All columns include country fixed effects. Standard errors are clustered at the country level. The sample covers the period 2014-2021.

**Local Projections** We turn to investigating the dynamics of pass-through from oil prices to retail fuel prices using the local projection method, following Jordà (2005). This approach is widely adopted as a flexible alternative that avoids the dynamic restrictions imposed by VAR or ARDL specifications. Moreover, it is less sensitive to misspecification in practice and is econometrically equivalent to a VAR (Plagborg-Møller and Wolf, 2021).[18]

Specifically, we estimate monthly inflation of retail fuel prices in USD following oil price shocks, which amounts to estimating the following reduced-form equation by OLS sequentially for each period $k$ on monthly panel data:

$$\Delta \ln P_{A,ct+k} = \varphi_c^k + \sum\nolimits_{i=1}^{l} \delta_i^k \Delta \ln P_{A,ct-i} + \sum\nolimits_{i=0}^{n} \beta_i^k \Delta \ln P_{O,t-i} + \epsilon_{ct}^k, \tag{11}$$

[18]Recent studies on the oil price pass-through that employed the local projection method include Choi et al., 2018;Sekine and Tsuruga, 2018;Kpodar and Liu, 2022;Baba and Lee, 2022;Alp et al., 2023 among others.

with $k = 0, 1, ...12$; $l = 3$; $n = 4$; $\Delta \ln P_{A,ct}$ is month-over-month after-tax USD retail price inflation in country $c$ and time $t$; $\Delta \ln P_{O,t}$ denotes month-over-month global crude oil price inflation in time $t$; $\varphi_c^k$ are country-level fixed effects; $\delta_i^k$ are supposed to capture the persistence of retail fuel price inflation.

Our coefficients of interest is $\widehat{\beta_0^k}$, which estimates the impact of changes in global oil prices on retail fuel price inflation for each future period $k$. As such, impulse response functions (IRFs) of the average effect of global oil price shocks on retail fuel price inflation can be obtained by plotting the estimated $\widehat{\beta_0^k}$ with confidence bands computed using the standard errors associated with the estimated coefficients.

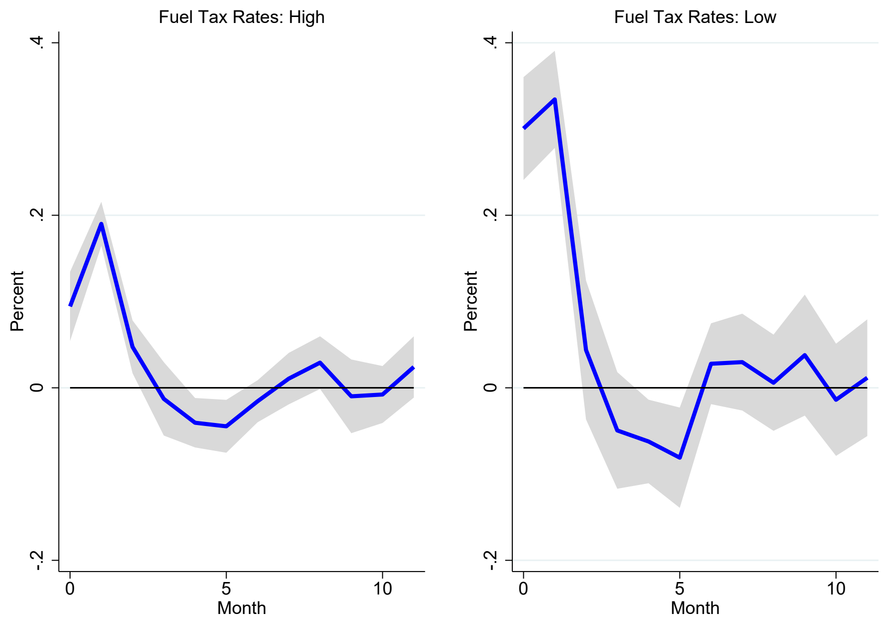
For illustrative purposes, we split the sample into high fuel tax (top 10 percentile) and low fuel tax (bottom 10 percentile countries) country groups, and estimate equation (11) separately for each group. Figure 8 summarizes the estimation results. For both gasoline (8a) and diesel (8b), the response of retail fuel price inflation to changes in global oil prices is greater in countries with lower fuel taxes compared to those with higher fuel taxes. The finding suggests that a one percentage point increase in the global crude oil price leads to around a 0.1 percentage point increase in retail fuel price inflation immediately in the same month and a 0.2 percentage point increase in the next month in high fuel tax countries. Interestingly, the impact nearly doubles in low fuel tax countries, resulting in around a 0.3 percentage point increase in retail fuel price inflation in both the same month and the next month. Moreover, the estimation results indicate that the pass-through to retail fuel price inflation diminishes within 2 months following the global oil price shock, consistent with the lag selection in earlier pass-through estimations.

Alternatively, instead of splitting the sample into two groups, we could put all the sample countries together in the estimation process and modify the local projection specification as:

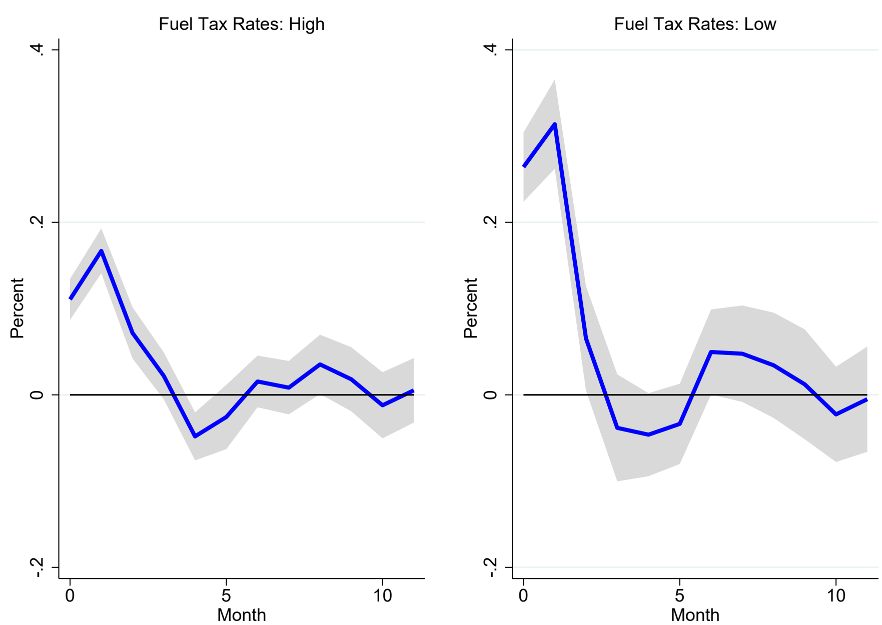
$$\Delta \ln P_{A,ct+k} = \varphi_c^k + \sum\nolimits_{i=1}^{l} \delta_i^k \Delta \ln P_{A,ct-i} + \sum\nolimits_{i=0}^{n} \left[ \beta_i^k \Delta \ln P_{O,t-i} + \gamma_i^k \Delta \ln P_{O,t-i} \times FuelTax_c \right] + \epsilon_{ct}^k \tag{12}$$

where the interaction term between the country-level average fuel tax rate and global crude oil price inflation is added to capture the extent to which the impact of changes in global oil prices on retail fuel price inflation varies with fuel tax rate levels. Our coefficients of interest is now $\widehat{\gamma_0^k}$.

Figure 8: Impulse Responses of Retail Prices by High and Low Fuel Tax Countries



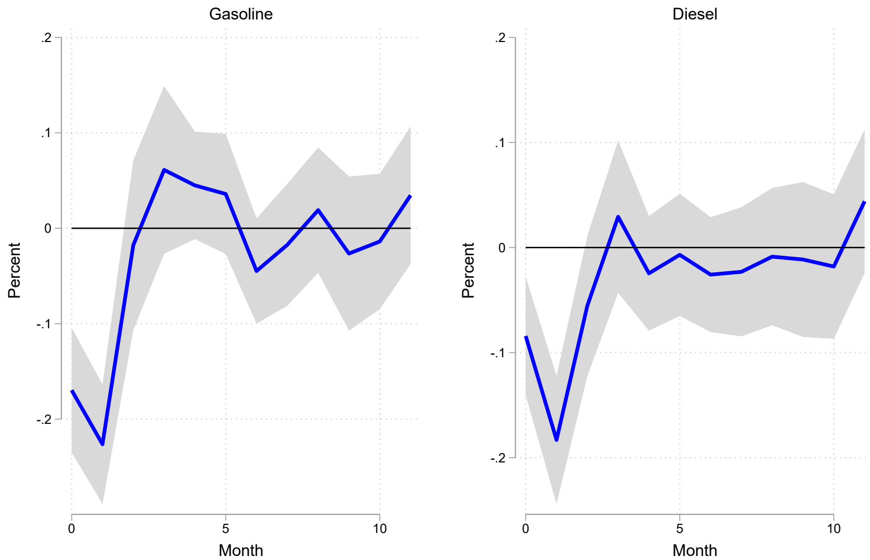

(a) Gasoline Retail Prices




(b) Diesel Retail Prices

Notes: This figure plots impulse response function of USD retail fuel price inflation (m-o-m) to crude oil prices from equation (11), separately for gasoline (8a) and diesel (8b) and for high fuel tax countries (left; top 10 percentile countries) and low fuel tax countries (right; bottom 10 percentile countries). Shaded area represents the 90% confidence interval.

Figure 9: Impulse Responses of Retail Prices: Interacted with Fuel Tax Rates



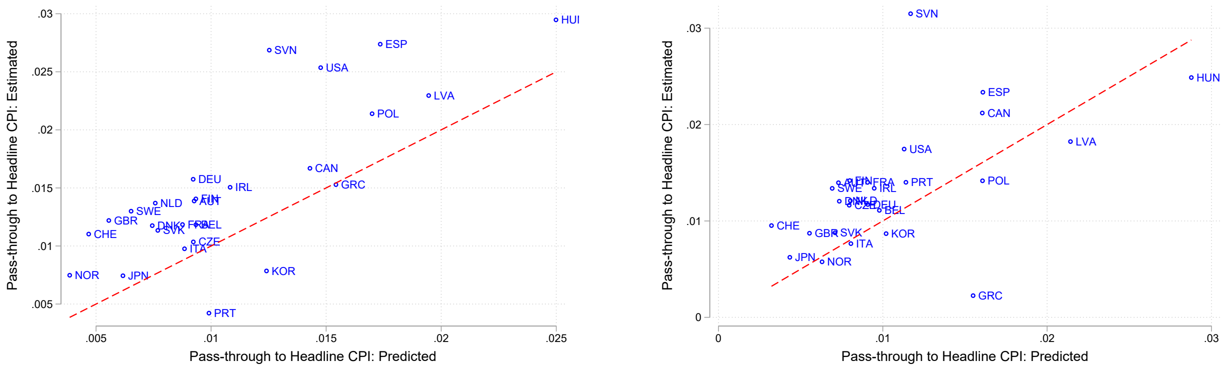

Notes: This figure plots impulse response function of USD retail fuel price inflation (m-o-m) to crude oil prices separately for gasoline (left) and diesel (right), as a linear function of fuel tax rates from equation (12). Shaded area represents the 90% confidence interval.

Estimation results summarized in Figure 9 confirm the role of fuel tax rates in determining the impact of changes in global oil prices on retail fuel price inflation: the response of USD gasoline price inflation to a one percentage point change in the global crude oil price is about 0.2 percentage point smaller in the first two months in countries with gasoline tax rates close to 1 dollar per liter compared to countries with gasoline tax rates close to zero. Similarly, the response of USD diesel price inflation to a one percentage point change in the global crude oil price is about 0.1 percentage point and 0.2 percentage point smaller in the same month and the next month, respectively, in countries with diesel tax rates close to 1 dollar per liter compared to countries with diesel tax rates close to zero. These differential effects disappear in two months after the shock as the pass-through to retail fuel price inflation diminishes.

## 4.2 CPI Inflation

**Pass-through Estimates** We move on to evaluating the oil price pass-through to CPI inflation beyond retail fuel prices. According to equations (6) and (7), we expect that the pass-through

Figure 10: Crude Oil Price Pass-through to Headline CPI: Predicted and Estimated




(a) Pass-through to Headline CPI (OLS)

(b) Pass-through to Headline CPI (ECM)

Notes: This figure plots the predicted (x-axis) and estimated (y-axis) degree of crude oil price pass-through to headline CPI inflation. Left panel is from simple OLS and right panel is from ARDL-ECM estimator. The red dashed line corresponds to the 45 degree line. The sample covers the period 2014-2021.

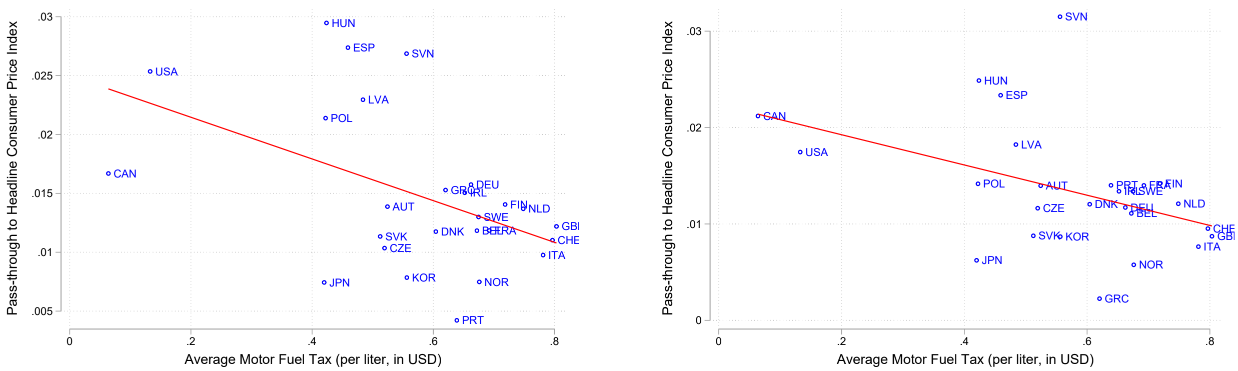
to headline CPI inflation would mainly reflect direct effects via retail fuel prices, influenced by the degree of pass-through to retail fuel prices in LCU and the CPI weight of motor fuel. This is precisely what Claim 2 implies. We validate this prediction by estimating equations (8) and (9) with the dependent variable replaced by month-over-month headline CPI inflation, and then compare these estimates to the predicted *direct* pass-through rate (i.e., the first term in equation (7)).

Figure 10 summarizes the comparison between the predicted and estimated oil price pass-through rates to headline CPI inflation. Left panel (10a) and right panel (10b) take estimation results from simple OLS and ARDL-ECM, respectively. In both panels, the y-axis corresponds to the estimated degree of oil price pass-through to headline CPI inflation in each country, while the x-axis corresponds to the predicted pass-through rate calculated by multiplying the country-level CPI weight of motor fuel by the country-level estimated price pass-through rate to LCU retail fuel prices.[19] A strong positive correlation between the predicted and estimated pass-through rates clearly suggests that the direct effect via retail fuel price is a predominant channel through which global oil price changes affect headline CPI inflation. Moreover, most countries are located above the red dashed 45 degree line, reflecting the presence of second-round effects through inflation spillovers to other sectors of the economy.

The predominant role of retail fuel prices in headline CPI inflation thus implies that the degree of global oil price pass-through to headline CPI inflation would be largely determined by motor

[19] As CPI weights of gasoline and diesel are not separately available in most sample countries, we take the simple average of the estimated pass-through rates to gasoline and diesel retail prices in each country.

Figure 11: Crude Oil Price Pass-through to Headline CPI and Tax Rates




(a) Pass-through and Tax Rates: Headline (OLS) (b) Pass-through and Tax Rates: Headline (ECM)

Notes: This figure plots country-level average fuel tax rates (x-axis) and the estimated degree of crude oil price pass-through to headline CPI (y-axis). The pass-through estimates in left and right panel are from simple OLS and ECM estimator, respectively. The OLS fitted line is drawn in red. The sample covers the period 2014-2021.

fuel tax rates. Figure 11 confirms that, irrespective of estimators, there exists a strong negative relationship between motor fuel tax rates on the x-axis and the estimated degree of oil price pass-through to headline CPI on the y-axis.[20]

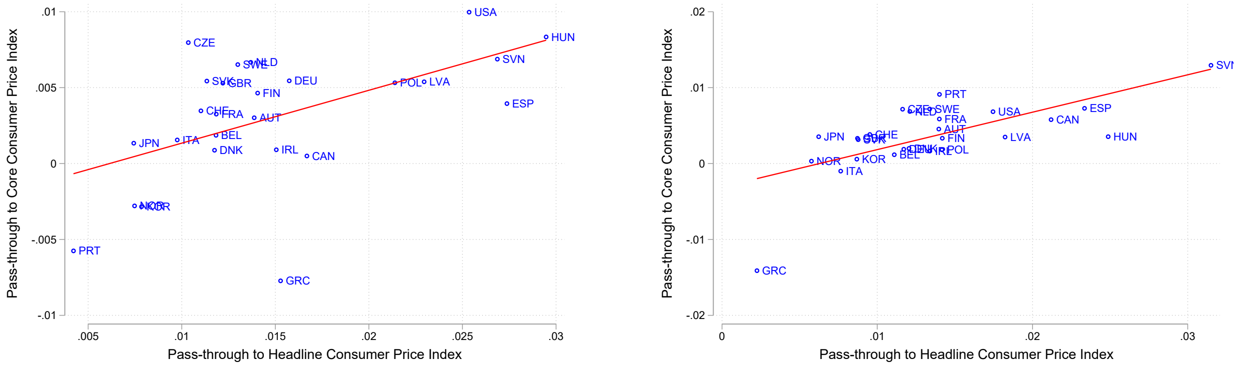
Moreover, the role of fuel tax rates could even go a long way toward affecting core CPI inflation. Figure 12 reveals, whether estimated by OLS (12a) or ARDL-ECM (12b) estimator, a strong positive relationship between the headline and core CPI pass-through rates, where the estimated oil price pass-through to core CPI inflation on the y-axis is obtained from estimating equations (8) and (9) with the dependent variable replaced by month-over-month core CPI inflation. This suggests that stronger (weaker) second-round effects may originate from a lower (higher) fuel tax rate initially.

To assess the effect of fuel tax rates on oil price pass-through to headline and core CPI inflation in a formal way, we estimate a modified version of equation (10) by replacing the dependent variable with month-over-month headline or core CPI inflation. Table (2) summarizes estimation results with $n$ set as 2 and standard errors clustered at the country level.

Column (1) shows that the average pass-through rate of global oil price to headline CPI inflation is estimated to be around 1.5% ($\approx (0.008 + 0.007) \times 100$). However, column (2) indicates substantial heterogeneity in the pass-through rate across countries as seen by statistically significant coefficient estimates on interaction terms. For countries with fuel tax rates close to zero, the pass-through rate is estimated to be as high as 2.8% ($\approx (0.014 + 0.014) \times 100$), whereas for countries with fuel

[20]Average motor fuel tax rates on the x-axis is a simple average of gasoline and diesel tax rates during the sample period.

Figure 12: Crude Oil Price Pass-through to Headline and Core CPI




(a) Pass-through to Headline and Core CPI (OLS) (b) Pass-through to Headline and Core CPI (ECM)

Notes: This figure plots the estimated degree of crude oil price pass-through to headline CPI (x-axis) and core CPI (y-axis). The pass-through estimates in left and right panel are from simple OLS and ECM estimator, respectively. The OLS fitted line is drawn in red. The sample covers the period 2014-2021.

tax rates close to one dollar per liter it is estimated to be as low as 0.5% ($\approx (0.014 - 0.011 + 0.014 - 0.012) \times 100$). As for core CPI inflation, column (3) reports that the average pass-through rate of oil prices is estimated to be around 0.4% ($\approx (0.002 + 0.002) \times 100$). According to column (4), however, there is substantial heterogeneity such that a country with fuel tax rates close to zero is expected to have a high pass-through rate of 0.8% ($\approx (0.002 + 0.006) \times 100$), whereas a pass-through rate in a country with fuel tax rates close to one dollar per liter is estimated to be 0 ($\approx (0.002 + 0.006 - 0.008) \times 100$).

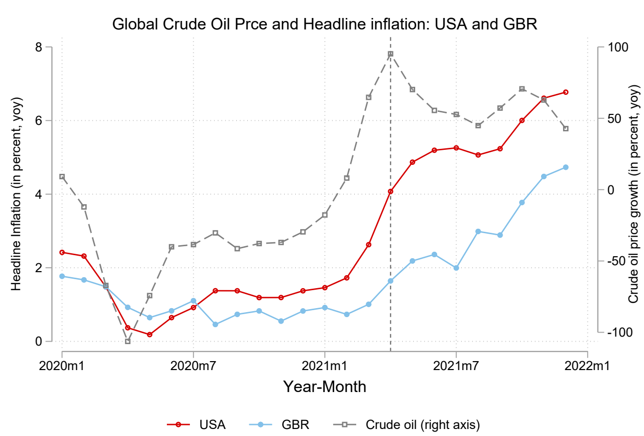
To gauge the quantitative significance of the estimation results, we can perform a simple back-of-the-envelope calculation regarding the onset of the recent world-wide surge in inflation. In 2021, average crude oil price spiked by 50% compared to the previous year, with varying degrees of annual headline CPI inflation across countries, for instance, from 2.5% in the UK to 4.7% in the US as illustrated in Figure (13). Considering that UK and US fuel tax rates were 0.8 and 0.13 dollar per liter, respectively, the crude oil price hike is estimated to have contributed to annual headline inflation by 0.48% in the UK and 1.25% in the US. The difference in oil price pass-through (0.77%) can thus account for about 30% of the difference in headline inflation observed in two countries (2.2%).

Table 2: Estimation Results: Crude Oil Price Pass-through to CPI and Tax Rates

| | Headline | | Core | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Crude Oil Price Growth | 0.008*** | 0.014*** | 0.002*** | 0.002** |
| | (0.001) | (0.002) | (0.001) | (0.001) |
| Crude Oil Price Growth | | -0.010*** | | -0.000 |
| X Average Tax Rate | | (0.002) | | (0.002) |
| 1-Month Lag Crude Oil Price Growth | 0.006*** | 0.013*** | 0.002** | 0.006*** |
| | (0.001) | (0.002) | (0.001) | (0.001) |
| 1-Month Lag Crude Oil Price Growth | | -0.012*** | | -0.008*** |
| X Average Tax Rate | | (0.003) | | (0.002) |
| 2-Month Lag Crude Oil Price Growth | 0.000 | -0.002 | -0.001 | -0.003 |
| | (0.001) | (0.003) | (0.001) | (0.002) |
| 2-Month Lag Crude Oil Price Growth | | 0.005 | | -0.003 |
| X Average Tax Rate | | (0.004) | | (0.002) |
| Observations | 2,444 | 2,444 | 2,444 | 2,444 |
| R-squared | 0.096 | 0.102 | 0.016 | 0.017 |

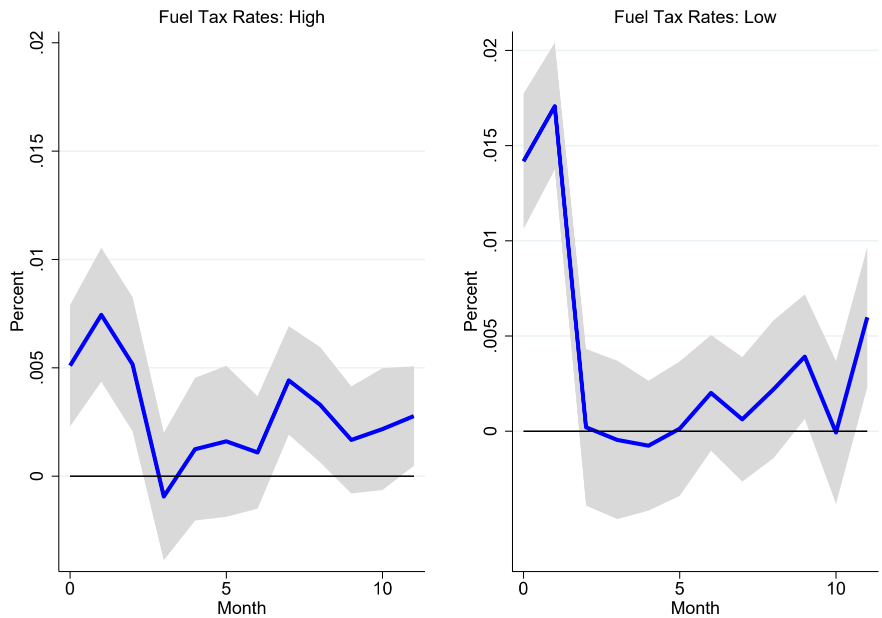
Notes: This table summarizes estimation results from a modified version of equation 10 where the dependent variable is monthly headline CPI inflation (columns (1)-(2)) or monthly core CPI inflation (columns (3)-(4)). All columns include country fixed effects. Standard errors are clustered at the country level. The sample covers the period 2014-2021.

Figure 13: Global Crude Oil Price and Headline CPI Inflation: US and UK

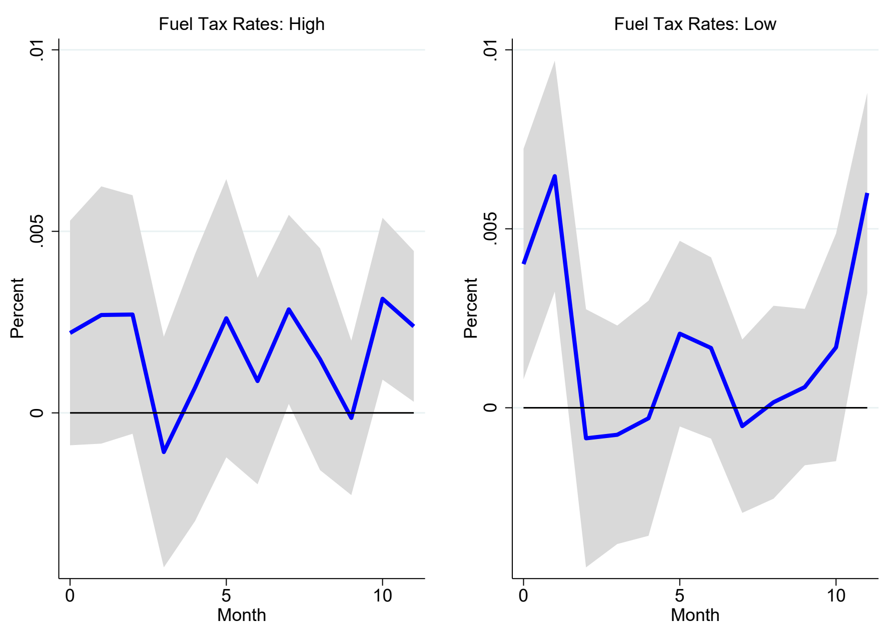



Notes: This figure plots the monthly year-on-year growth of headline CPI inflation in the US and UK (left axis) alongside global crude oil price growth (right axis) for the period 2020-2021.

Figure 14: Impulse Responses of Headline and Core CPI by High and Low Fuel Tax Countries



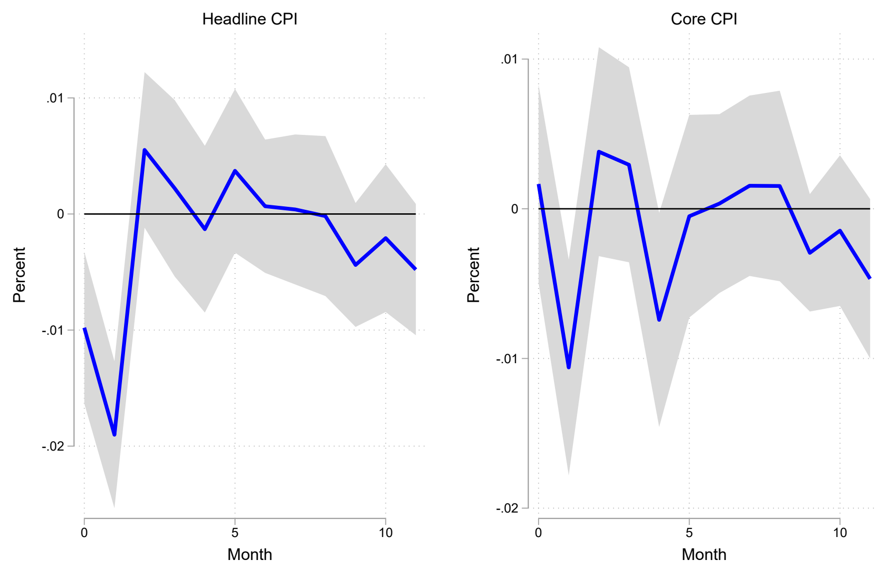

(a) Headline CPI




(b) Core CPI

Notes: This figure plots impulse response function of CPI inflation (m-o-m) to crude oil prices from equation (13), separately for headline (14a) and core CPI (14b) and for high fuel tax countries (left; top 10 percentile countries) and low fuel tax countries (right; bottom 10 percentile countries). Shaded area represents the 90% confidence interval.

Figure 15: Impulse Responses of Headline and Core CPI: Interacted with Fuel Tax Rates




Notes: This figure plots impulse response function of CPI inflation (m-o-m) to crude oil prices separately for headline (left) and core CPI (right), as a linear function of fuel tax rates from equation (14). Shaded area represents the 90% confidence interval.

**Local Projections** We can also explore the dynamics of pass-through from oil prices to CPI by modifying the local projection method specification in equation (11) as below, thereby estimating monthly CPI inflation following oil price shocks:

$$\Delta \ln P_{CPI,ct+k} = \varphi_c^k + \sum\nolimits_{i=1}^{l} \delta_i^k \Delta \ln P_{CPI,ct-i} + \sum\nolimits_{i=0}^{n} \beta_i^k \Delta \ln P_{O,t-i} + \epsilon_{ct}^k, \tag{13}$$

with $k = 0, 1, ...12$; $l = 3$; $n = 4$; $\Delta \ln P_{CPI,ct}$ is month-over-month headline or core CPI inflation in country $c$ and time $t$; $\Delta \ln P_{O,t}$ denotes month-over-month global crude oil price inflation in time $t$; $\varphi_c^k$ are country-level fixed effects; $\delta_i^k$ are supposed to captures the persistence of domestic CPI inflation.

Our coefficients of interest is $\widehat{\beta_0^k}$, which estimate the impact of changes in global oil prices on CPI inflation for each future period $k$. As such, impulse response functions (IRFs) of the average effect of global oil price shocks on CPI inflation can be obtained by plotting the estimated $\widehat{\beta_0^k}$ with confidence bands computed using the standard errors associated with the estimated coefficients.

For illustrative purposes, we split the sample into high fuel tax (top 10 percentile) and low fuel tax (bottom 10 percentile countries) country groups, and estimate equation (13) separately for each group. Figure 14 summarizes the estimation results for headline CPI (14a) and core CPI (14b).

The response of headline CPI inflation to the changes in global oil prices is greater in low fuel tax countries than in high fuel tax countries. The finding suggests that a one percentage point increase in the global crude oil price leads to around a 0.005 percentage point increase in headline CPI inflation immediately in the same month, and about 0.075 and 0.05 percentage point increases in the following two months, respectively, in high fuel tax countries. More interestingly, the impact almost more than doubles in low fuel tax countries as it leads to around a 0.015 percentage point increase in headline CPI inflation in the same month as well as the next month. Moreover, the estimation results show that the pass-through to headline CPI inflation diminishes within two months after the global oil price shock, consistent with the lag selection in earlier pass-through estimations.

The response of core CPI inflation to changes in global oil prices is also greater in low fuel tax countries than in high fuel tax countries. Although core CPI inflation is hardly affected by changes in the global crude oil price in high fuel tax countries, in low fuel tax countries, core CPI inflation increases by approximately 0.1 percentage point in the first two months in response to a one percentage point increase in the global oil price.

Instead of splitting the sample into two groups, we put all the sample countries together in the estimation process to estimate the extent to which the impact of changes in global oil prices on CPI inflation varies with fuel tax rate levels, by modifying the local projection specification in equation (12) as below:

$$\Delta \ln P_{CPI,ct+k} = \varphi_c^k + \sum_{i=1}^{l} \delta_i^k \Delta \ln P_{CPI,ct-i} + \sum_{i=0}^{n} \left[ \beta_i^k \Delta \ln P_{O,t-i} + \gamma_i^k \Delta \ln P_{O,t-i} \times FuelTax_c \right] + \epsilon_{ct}^k \tag{14}$$

where the interaction term between the country-level average fuel tax rate and global crude oil price inflation is added Our coefficients of interest is now $\widehat{\gamma_0^k}$.

Estimation results summarized in Figure 15 confirms that fuel tax rates also affects the impact of changes in global oil prices on CPI inflation: the response of headline CPI inflation to a one percentage point change in the global crude oil price is about 0.01 and 0.02 percentage point smaller in the same month and the following month, respectively, in countries with fuel tax rates close to 1 dollar per liter compared to countries with fuel tax rates close to zero. In contrast, the response of core CPI inflation to a one percentage point change in the global crude oil price is not different across countries in the same month, but, in the following month, it is 0.01 percentage point smaller in countries with fuel tax rate close to 1 dollar per liter compared to countries with fuel tax rates close to zero.

## 5 Conclusion

Carbon taxation, aimed at mitigating the negative externalities of greenhouse gas emissions, remains highly controversial, both politically and economically. The potential inflationary pressure it poses is a primary concern among policymakers. When applied for fuel excise taxes, it is expected to immediately raise retail fuel prices, potentially leading to short-term inflationary increases with regressive distributional implications.

Nevertheless, the main findings in this paper provide supportive evidence that it could reduce inflation volatility stemming from oil price shocks, thereby potentially enhancing welfare and allowing for more consistent monetary policy. Employing fuel tax rate and retail fuel price datasets that cover both gasoline and diesel for 28 OECD countries over the period of 2014 to 2021, this paper reveals the role of fuel excise taxes as a shock absorber, reducing the impact of global oil price shocks on domestic inflation, thereby influencing the extent of crude oil price pass-through. The estimation results suggest that the fuel excise tax channel is quantitatively significant enough to explain about 30% of the difference in annual headline CPI inflation rates observed in the U.S. (4.7%) and U.K. (2.5%) during the 2021 inflation surge. Moving forward, the main findings of this paper emphasize the importance for policymakers to consider the potential role of carbon taxes as a shock absorber for commodity prices.

## References


Aastveit, K. A., H. C. Bjørnland, and J. L. Cross (2023): "Inflation Expectations and the Pass-through of Oil Prices," *Review of Economics and Statistics*, 105, 733–743.

Ahn, J. and J. Lee (2023): "The Role of Import Prices in Flattening the Phillips Curve: Evidence from Korea," *Journal of Asian Economics*, 86, 101605.

Ahn, J., C.-G. Park, and C. Park (2017): "Pass-through of Imported Input Prices to Domestic Producer Prices: Evidence from Sector-level Data," *The BE Journal of Macroeconomics*, 17, 20160034.

Alp, H., M. Klepacz, and A. Saxena (2023): "Second-Round Effects of Oil Prices on Inflation in the Advanced Foreign Economies," FEDS Notes.

Ari, M. A., M. N. Arregui, M. S. Black, O. Celasun, M. D. M. Iakova, M. A. Mineshima, V. Mylonas, I. W. Parry, I. Teodoru, and K. Zhunussova (2022): "Surging Energy Prices in Europe in the Aftermath of the War: How to Support the Vulnerable and Speed up the Transition away from Fossil Fuels," IMF Working Paper.

Baba, C. and J. Lee (2022): "Second-Round Effects of Oil Price Shocks–Implications for Europe's Inflation Outlook," IMF Working Paper.

Black, M. S., D. N. Minnett, I. W. Parry, M. J. Roaf, and K. Zhunussova (2022): *A Framework for Comparing Climate Mitigation Policies across Countries*, International Monetary Fund.

Blanchard, O. J. and B. S. Bernanke (2023): "What Caused the US Pandemic-era Inflation?" NBER Working Paper.

Campa, J. M. and L. S. Goldberg (2005): "Exchange Rate Pass-through into Import Prices," *Review of Economics and Statistics*, 87, 679–690.

Chen, S.-S. (2009): "Oil Price Pass-through into Inflation," *Energy economics*, 31, 126–133.

Choi, S., D. Furceri, P. Loungani, S. Mishra, and M. Poplawski-Ribeiro (2018): "Oil Prices and Inflation Dynamics: Evidence from Advanced and Developing Economies," *Journal of International Money and Finance*, 82, 71–96.

Conflitti, C. and M. Luciani (2019): "Oil Price Pass-through into Core Inflation," *The Energy Journal*, 40, 221–248.

Dao, M., A. Dizioli, C. Jackson, D. Leigh, and P.-O. Gourinchas (2023): “Unconventional Fiscal Policy in Times of High Inflation,” IMF Working Paper.

Del Granado, F. J. A., D. Coady, and R. Gillingham (2012): “The Unequal Benefits of Fuel Subsidies: A Review of Evidence for Developing Countries,” *World development*, 40, 2234–2248.

Del Negro, M., J. Di Giovanni, and K. Dogra (2023): “Is the Green Transition Inflationary?” *FRB of New York Staff Report*.

Erceg, C., M. Kolasa, J. Lindé, and A. Pescatori (2024): “Can Energy Subsidies Help Slay Inflation?” .

Gautier, E., M. Marx, and P. Vertier (2023): “How do Gasoline Prices Respond to a Cost Shock?” *Journal of Political Economy Macroeconomics*, 1, 707–741.

Ha, J., M. A. Kose, and F. Ohnsorge (2023a): “One-stop Source: A Global Database of Inflation,” *Journal of International Money and Finance*, 102896.

Ha, J., M. A. Kose, F. Ohnsorge, and H. Yilmazkuday (2023b): “Understanding the Global Drivers of Inflation: How Important are Oil Prices?” World Bank Policy Research Working Paper.

IMF (2022): “Near-term Macroeconomic Impact of Decarbonization Policies,” World Economic Outlook (October), Chapter 3.

——— (2023): “External Sector Implications of the Global Dollar Cycle,” External Sector Report, Chapter 2.

IMF and OECD (2021): “Tax Policy and Climate Change,” IMF/OECD Report for the G20 Finance Ministers and Central Bank Governors.

Jordà, Ò. (2005): “Estimation and Inference of Impulse Responses by Local Projections,” *American Economic Review*, 95, 161–182.

Kilian, L. and X. Zhou (2022): “The Impact of Rising Oil Prices on US Inflation and Inflation Expectations in 2020–23,” *Energy Economics*, 113, 106228.

——— (2023): “Oil Price Shocks and Inflation,” FRB of Dallas Working Paper.

Klenert, D., G. Schwerhoff, O. Edenhofer, and L. Mattauch (2018): “Environmental Taxation, Inequality and Engel’s Law: The Double Dividend of Redistribution,” *Environmental and Resource Economics*, 71, 605–624.

Knittel, C. R. (2012): "Reducing Petroleum Consumption from Transportation," *Journal of Economic Perspectives*, 26, 93–118.

Knittel, C. R. and R. Sandler (2018): "The Welfare Impact of Second-best Uniform-Pigouvian Taxation: Evidence from Transportation," *American Economic Journal: Economic Policy*, 10, 211–242.

Konradt, M., T. McGregor, and F. Toscani (2024): "Carbon Prices and Inflation in the Euro Area," IMF Working Paper.

Konradt, M. and B. Weder di Mauro (2023): "Carbon Taxation and Greenflation: Evidence from Europe and Canada," *Journal of the European Economic Association*, jvad020.

Kpodar, K. and C. Abdallah (2017): "Dynamic Fuel Price Pass-through: Evidence from a New Global Retail Fuel Price Database," *Energy Economics*, 66, 303–312.

Kpodar, K. and P. A. Imam (2021): "To pass (or not to pass) through International Fuel Price Changes to Domestic Fuel Prices in Developing Countries: What are the Drivers?" *Energy Policy*, 149, 111999.

Kpodar, K. and B. Liu (2022): "The Distributional Implications of the Impact of Fuel Price Increases on Inflation," *Energy Economics*, 108, 105909.

Millischer, L., C. Fu, U. Volz, and J. Beirne (2024): "Do Renewables Shield Inflation from Fossil Fuel-Price Fluctuations?" .

Moessner, R. (2022): "Effects of Carbon Pricing on Inflation," CESifo Working Paper.

Nakamura, E. and D. Zerom (2010): "Accounting for Incomplete Pass-through," *The review of economic studies*, 77, 1192–1230.

Obstfeld, M. and H. Zhou (2023): "The Global Dollar Cycle," NBER Working Paper.

Parry, I. (2019): *What Is Carbon Taxation?*, Finance & Development.

Parry, I. W., M. D. Heine, E. Lis, and S. Li (2014): *Getting Energy Prices Right: From Principle to Practice*, International Monetary Fund.

Plagborg-Møller, M. and C. K. Wolf (2021): "Local Projections and VARs Estimate the Same Impulse Responses," *Econometrica*, 89, 955–980.

Santabárbara, D. and M. Suárez-Varela (2022): *Carbon Pricing and Inflation volatility*, Banco de Espana Working Paper.

Schnabel, I. (2022): "Looking through Higher Energy Prices? Monetary Policy and the Green Transition." Speech at a panel on "Climate and the Financial System" at the American Finance Association 2022 Virtual Annual Meeting.

Sekine, A. and T. Tsuruga (2018): "Effects of Commodity Price Shocks on Inflation: A Cross-country Analysis," *Oxford Economic Papers*, 70, 1108–1135.

Sgaravatti, G., S. Tagliapietra, and G. Zachmann (2023): "National Fiscal Policy Responses to the Energy Crisis," *Brussels: Bruegel*.

Smith, D. T. (1952): "Note on Inflationary Consequences of High Taxation," *The Review of Economics and Statistics*, 243–247.

Sterner, T. (2012): *Fuel Taxes and the Poor: The Distributional Effects of Gasoline Taxation and their Implications for Climate Policy*, Routledge.

Tsvetanov, T. (2024): "Tax Holidays and the Heterogeneous Pass-through of Gasoline Taxes," *Energy Economics*, 107682.

Vlieghe, G. (2024): *Core Strength: International Evidence on the Impact of Energy Prices on Core Inflation*.

Yilmazkuday, H. (2021): "Oil Price Pass-through into Consumer Prices: Evidence from US Weekly Data," *Journal of International Money and Finance*, 119, 102494.

PUBLICATIONS

**Greenflation or Greensulation? The Case of Fuel Excise Taxes and Oil Price Pass-through**
Working Paper No. WP/2024/153