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## Dynamic Fuel Price Pass-Through: Evidence from a New Global Retail Fuel Price Database

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**Dynamic Fuel Price Pass-Through: Evidence from a New Global Retail Fuel Price Database[1]**

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**Abstract**

This paper assesses the dynamic pass-through of crude oil price shocks to retail fuel prices using a novel database on monthly retail fuel prices for 162 countries. The impulse response functions suggest that on average, a one cent increase in crude oil prices per liter translates into a 1.2 cent increase in the retail gasoline price at peak level six months after the shock. However, the estimates vary significantly across country groups, ranging from about 0.5 cent in MENA countries to two cents in advanced economies. The results also show that positive oil price shocks have a larger impact than negative price shocks on the retail gasoline price. Finally, the paper underscores the importance of the new dataset in refining estimates of the fiscal cost of incomplete pass-through.

JEL Classification Numbers: L71; Q48; H23

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## I. INTRODUCTION

**The economic consequences and policy responses to international oil price movements have been at the forefront of the policy debate for decades.** Existing studies (e.g. Coady et al., 2010; Clements et al., 2013) find that many countries have failed to pass through higher international oil prices to consumers, with significant implications for fiscal sustainability. However, a key hurdle for assessing the responses of domestic fuel prices to international oil price shocks has been the lack of comprehensive and high frequency time series and cross-country data on retail fuel prices. For this reason, existing studies using high frequency data have been limited mostly to advanced economies, and when a broader sample was considered, the pass-through analysis was done focusing on annual data.

**What is the impact of crude oil price changes on retail fuel prices?** How fast has this impact fed through to domestic fuel prices? Do consumers benefit from a decline in crude oil prices to the same extent that they incur the cost of an increase in crude oil prices? These are important questions to address in order to better understand the transmission of crude oil price shocks to retail fuel prices given the stark differences in retail fuel prices across countries. Against this backdrop, this paper assesses the dynamic of pass-through of crude oil price shocks in a large sample to offer insights on the magnitude of retail fuel price responses in the short and medium-term, the speed of adjustment, potential asymmetric responses, and how these characteristics vary across regions and income groups. To do so, we compile a novel database on monthly retail fuel prices for four main petroleum products: gasoline, diesel, kerosene, and Liquefied Petroleum Gas (LPG). The database covers 162 countries with monthly data for most countries starting from the early 2000s until December 2014, and for a few countries data goes as far back as the 1970s.

**This paper contributes to the literature in several important ways. First, it confirms the findings of pass-through estimates from previous studies using the static approach.** Second, the paper estimates impulse response functions of domestic retail gasoline prices, and then differentiates between positive and negative crude oil price shocks to investigate whether retail gasoline prices respond the same way or not when crude oil prices rise or fall. Third, to analyze the pass-through dynamic, this paper compiles a new dataset on retail fuel prices and, in doing so, it addresses the gaps in existing databases which lack high-frequency data (as they are available mostly at the annual level), and most of them also tend to have a narrow coverage or a short time span. The relevance of the new database goes beyond the scope of this paper as it will stimulate further research on fuel pricing and subsidy reform issues as well as studies looking at the macroeconomic effects of fuel price shocks. Finally, using the new database, the paper highlights the importance of taking into account within-year price changes in the calculation of the fiscal cost of incomplete pass-through.

**In line with past studies, the paper finds that the pass-through of crude oil price changes to domestic fuel prices is the lowest in the Middle East and North Africa (MENA) region where major oil exporters heavily subsidize retail prices, whereas advanced economies and emerging Europe have the highest pass-through.** Among fuel products, gasoline pass-through is in most cases larger than that of diesel and kerosene in developing economies, reflecting most likely differences in taxation as these products are considered sensitive for the poor, and therefore are more subsidized.

**Further, our analysis reveals interesting new findings. The pass-through of the drop in international oil prices (starting from the second half of 2014) has been especially low in developing economies at end-2014, possibly because countries are taking advantage of low oil prices to rebuild fiscal buffers.** Comparing the pass-through across different periods points to an asymmetry as the pass-through during periods of rising oil prices is generally higher than during periods of declining oil prices. Nevertheless, the static approach overlooks the dynamic features of pass-through. Therefore, by taking advantage of the high frequency of the new dataset, the estimation of the impulse response functions (using the local projection approach by Jorda, 2005) shows that the transmission of a transitory shock in crude oil prices to retail fuel prices follows a hump-shaped curve with the peak pass-through being reached within six months after the shock. The effect decays gradually and tends to remain persistent in the medium-term, although there are differences across regions and income groups. The asymmetry of pass-through is also confirmed as positive oil price shocks are passed through to retail prices quicker and stronger than negative price shocks. Finally, the fiscal cost of incomplete pass-through based on end-of-year retail fuel prices—as done in studies using snapshot of annual prices—often underestimates the true fiscal cost compared to when using the yearly average retail fuel prices (for instance, by up to 1.4 percent of GDP on average in 2008). This highlights the relevance of the new dataset in refining fuel subsidy estimates.

**The paper is organized as follows. Section II introduces the new database, and describes the data sources and methodology to ensure comparability across countries.** This section also offers some stylized facts on cross-country comparison of price levels and trends. Section III follows with an analysis of how countries have responded to change in international oil prices over time using both the static and dynamic approach. Further, the sensitivity of the fiscal cost of incomplete pass-through to the end-of-year and average retail fuel prices is examined. Section IV summarizes and concludes.

## II. The New Global Database on Retail Fuel Prices

**A number of retail fuel price databases exist (see Appendix 1 for a description).** They include institutional databases such as the one provided by the German Agency for International Cooperation[3] (GIZ), but also datasets from specific studies (e.g. Coady et *al.*, 2010; Ross, Hazlett and Mahdavi, 2015). However, crude oil prices are subject to significant short-term volatility, and assessing how the variations are passed through to consumers requires high frequency data over a relatively long period, a feature most existing databases lack. Moreover, the size of the country samples, and the coverage of fuel products are other limiting factors. The fact that none of the existing databases offer comprehensive data along all four dimensions combined (frequency, time horizon, country sample, and coverage of fuel products) have restricted the scope of previous pass-through studies.[4]

[3] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

[4] Ross, Hazlett and Mahdavi (2015) compile monthly data on retail gasoline price for 157 countries. However, their database does not include data on diesel, kerosene and LPG prices.

**To overcome these constraints, this paper presents a new dataset on retail fuel prices covering monthly data for a large set of (162) countries over a relatively long period for four different fuel products: gasoline, diesel, kerosene and LPG.** The following section discusses the primary sources of the data as well as the methodology of compilation to construct the time series on retail prices and ensure comparability across countries.

## A. Data Sources and Methodology

**This database was constructed by relying primarily on data made available publicly online by country authorities, but which often are not easily accessible because of the diversity of institutions involved, varying from one country to another.** These include regulatory agencies in charge of fuel pricing regulation, consumer protection entities, ministries of finance, ministries of trade, ministries of energy, state-owned petroleum companies or refineries, national statistics agencies, and central banks.

**The institutional arrangement for publication of fuel price data reflects to a large extent the pricing mechanism in place.** Where governments retain control on fuel prices, new prices are released by regulatory agencies, ministries or relevant State-Owned Enterprises (SOEs). Whereas when prices are liberalized, consumer protection bodies report ex post or real-time fuel prices to assess competition among distributors and monitor uncompetitive behaviors. Whether prices are controlled or not, national statistical agencies and/or central banks often collect fuel price data,[5] as key inputs to the calculation of the consumer price index and monitoring of inflation developments. In addition to the challenge of identifying the specific institution that publishes fuel price data, difficulties in collecting data are compounded by the lack of a single repository for historical data as changes in controlled prices are often communicated to the public through press releases. For many advanced economies, comprehensive fuel price data are readily available through existing datasets, which makes it less relevant to source these data from individual country institutions. As a result, our database simply reports the same series and clearly indicates the sources of the data.

**While a growing number of countries have started to publish retail fuel prices to improve price transparency, a fairly significant number of countries, largely in the developing world, are still lagging behind.** For those countries, we rely on data collected by IMF staff.[6] About 40 percent of the countries in the database post retail fuel price information online, of which about half are published by state-owned petroleum companies and regulatory agencies. IMF staff are the second most important source of price information with close to 40 percent of the total sample, followed by existing databases which account for about 30 percent of the sample. The remaining data are sourced mostly through press coverage.

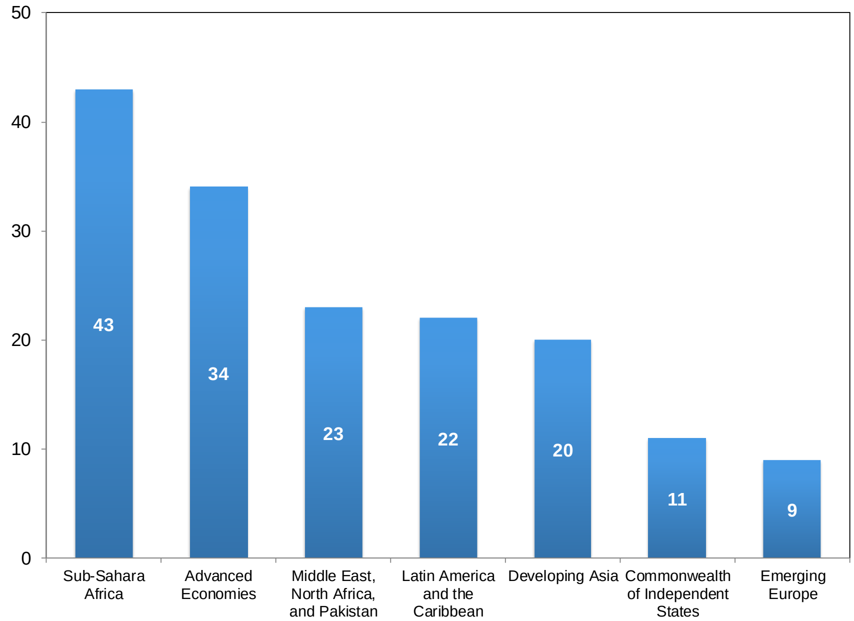
**The sample is diverse in terms of geographical coverage and income levels (Figure 1).** Sub-Saharan African (SSA) countries and advanced economies are the largest country groups,

[5] Although they do not necessarily make them public.

[6] The primary sources of the data are country authorities, with the difference that they do not make them publicly available through any of the channels discussed above.

accounting for respectively 27 and 21 percent of the sample (see Appendix 2 for the composition of country groups).[7] Developing Asia, Latin American, and the Middle-East and North Africa (MENA)[8] regions are also well represented, with about 14 percent of the sample for each group.

**Figure 1. Sample Composition by Country Groups**




Note: Sample composition based on 2014 monthly data
Source: Authors' calculations

**The database constitutes an unbalanced panel of countries over the period January 1970–December 2014 for a total of more than 65,000 monthly observations for all four fuel products considered.** However, time series availability varies by country and products. As shown in Figure 2, data are available for most countries starting from the early 2000s. Gasoline and diesel price data make up the bulk of the dataset; respectively 35 and 34 percent of total observations.

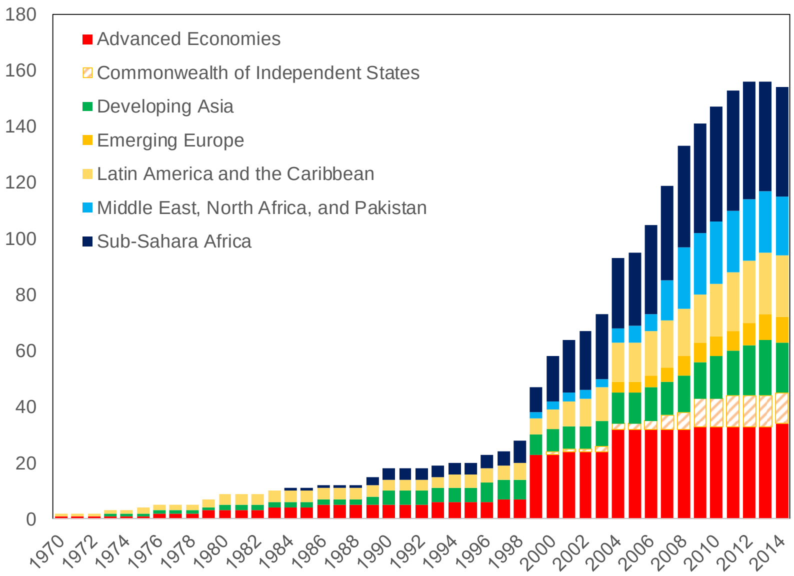
**We have fewer data points on kerosene price (19 percent of the observations) as kerosene is not used by households in countries where there are better alternatives for cooking and lighting fuels.** For LPG prices (12 percent of the observations), the lack of available information, mainly on developing countries, hampered data collection. This may reflect several factors: (i) relatively low household consumption of LPG compared to other fuel products weakens incentives for country authorities to track prices and report them; this is also the case when LPG prices rarely change because of government control; (ii) LPG market is often segmented, with prices (per unit, e.g. kg) varying by quantities (canister size) owing to a differentiated government subsidy, which makes it challenging to produce reliable information on prices; and (iii) collecting

[7] The country groups are consistent with the IMF World Economic Outlook classification.

[8] The MENA group also includes Pakistan.

data is more costly when LPG prices are liberalized, a cost which countries may not be willing to incur, especially when consumption is marginal.

**Figure 2. Number of Countries by Year, 1970–2014**




Source: Authors' calculations

**The database contains end-user prices in national currencies all tax inclusive.**[9] The data are compiled without recourse to extrapolation, interpolation, or regressions. They reflect prices paid by households and firms at the pump,[10] and exclude discounts and any rebates distributors might offer. Gasoline, diesel, and kerosene prices are denominated in local currency unit (LCU) per liter, whereas LPG prices are in LCU per kg (except for motor LPG which is in LCU per liter).

**Nevertheless, to ensure comparability of data across countries, some adjustments to the original data have been made.** These include:

- *Averaging prices*. For countries reporting daily or weekly fuel prices, the monthly prices are calculated as the average over the month. When government controls prices, and there is more than one change in a month, the monthly prices are the average of the prices with the exception that when the price change occurred in the last week of the month this data point is excluded from the calculation of the average of that month and is reported for the following month. In addition, since there are several grades of

[9] Data on fuel taxes are not available to derive pump prices before taxes.

[10] Fuel for specific consumers (e.g. fishing industry, electricity producers, farmers, and so forth) may be sold below pump prices.

gasoline and diesel, and some grades are phased out while new ones are introduced; we averaged prices across grades over time to limit breaks in the series.[11]

- *Harmonizing units of measurement*. When prices are denominated in LCU per US gallon or Imperial gallon, they are converted into LCU per liter using the conversion factor of 1US gallon for 3.78 liters, and 1 Imperial gallon for 4.54 liters. A complication with LPG prices is that, unlike gasoline, diesel and kerosene, prices per kg vary with quantities. Therefore, we took the unit price of the most commonly available canister size used by households across countries, which is about 12kg or 25 lbs.

- *Adjusting for currency change*. Historical retail fuel price data in LCU are significantly affected by currency redenomination or the adoption of a new currency; therefore, we adjusted the prices back before those events with the appropriate conversion factor. Moreover, where fuels are priced in U.S. dollars, we used the prevailing official exchange rate to convert prices into LCU.

**The database tracks actual average country-wide prices paid by consumers, with a few exceptions.** When national price survey data are not available, the database reports average prices in the capital city. Although prices in other cities may be higher owing to transport cost, prices in the capital remain a good proxy for national averages given that it is generally the main center of consumption. In countries where the government imposes a price ceiling for fuel products, actual prices paid by consumers can be below the ceiling, reflecting competition among distributors, but the gap is likely to be negligible. In periods of fuel shortages or when smuggling is widespread, retail fuel prices can be markedly higher or cheaper than official prices, but the lack of available information prevent from capturing these cases. The full database is available upon request along with details on the sources of price information and, if available, the link where the data are posted by country authorities.

### B. Fuel Price Levels and Changes: Stylized Facts

**Advanced economies and emerging Europe feature the highest average retail fuel prices (Table 1), but the United States is an outlier with the lowest gasoline and diesel prices among advanced economies thanks to both reduced supply costs and lower fuel taxes.** On the opposite end of the spectrum, MENA countries exhibit the lowest retail prices for all fuel products—major oil producers in the region using revenues from oil exports to heavily subsidize domestic prices, followed by Latin American countries. Sub-Saharan African countries have the highest average fuel prices among developing countries, more than twice than those of MENA countries.[12] This is not entirely explained by higher fuel taxation, but also the fact that many

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[11] The lack of data on quantities consumed prevents from calculating the volume-weighted average prices. However, since the price spread between different grades of the same product is relatively small, using a simple average is appropriate. When there is strong evidence that the price of one fuel grade (typically premium grade) is subject to market forces, while the prices for the other grades are regulated, the later are reported.

[12] Average LPG price is relatively low in developing Asia, because of heavy subsidies to encourage the use of LPG as an alternative fuel for transportation and cooking. Household consumption of LPG was also encouraged by

African countries face a high supply cost owing to lack of economies of scale, a high cost of transport and storage, and in some cases high refinery production cost.

**Table 1. Average Retail Fuel Price by Country Groups, January–December, 2014**

| | Gasoline | Diesel | Kerosene | LPG |
|---|---|---|---|---|
| | (USD per liter) | | | (USD per kg) |
| Advanced Economies | 1.9 | 1.7 | 1.5 | .. |
| Commonwealth of Independent States | 0.9 | 1.0 | 1.0 | .. |
| Developing Asia | 1.2 | 1.1 | 1.0 | 1.5 |
| Emerging Europe | 1.8 | 1.8 | .. | .. |
| Latin America and the Caribbean | 1.1 | 1.0 | 1.0 | 1.1 |
| Middle East and North Africa | 0.7 | 0.6 | 0.5 | 0.2 |
| Sub-Saharan Africa | 1.4 | 1.3 | 1.1 | 1.4 |
| World average | 1.3 | 1.2 | 0.9 | 1.2 |
| *Memo item* | | | | |
| United States | 0.9 | 1.0 | … | … |

Note: LPG refers to cooking gas sold in cylinders
Source: Authors' calculations

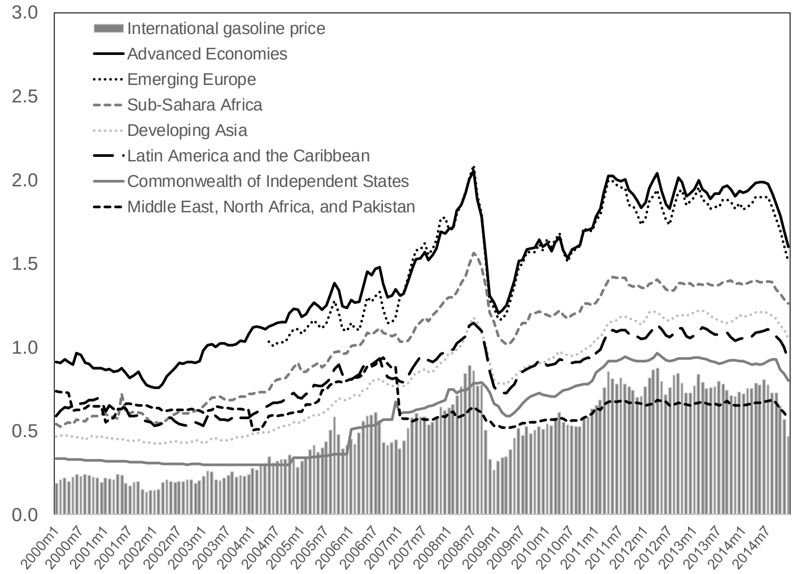
**It is also interesting to look at the trends in average retail fuel prices in the different regions over time (Figure 3).** Despite the sharp decline in international oil prices in 2014, evidence of pre-tax subsidies was apparent in 15 percent of the countries in the sample as retail gasoline prices were below the international gasoline price (mostly in the MENA region). For countries with retail prices above international levels, plus a mark-up for transport cost and margins, a tax subsidy is likely as fuel tax in many countries are far below the efficient tax level.[13]

**Figure 3 suggests that retail fuel prices do respond to changes in international oil prices to a varying degree, which raises the interesting question on how countries have responded to oil price shocks.** This is particularly important as failure to fully pass through high oil prices have led to sizeable fiscal costs, which crowded out priority expenditure and heightened fiscal imbalances.

low prices, given the environmental benefits compared to traditional fuels for cooking such as wood and charcoal.

[13] When a pre-tax subsidy exists, post-tax subsidy is the sum of the efficient tax and the pre-tax subsidy. In the absence of pre-tax subsidy, consumer prices are higher than supply cost, hence post-tax subsidy is the gap between efficient and actual taxation (for detailed discussions about the definition and estimates of pre- and post-tax subsidy, see Clements et al., 2013). The efficient taxation level is the one that reflects both revenue needs and a correction for negative externalities associated with the consumption of fuel products (e.g. environmental damage including global warming and air pollution, and road accidents). Parry *et al.* (2014) provide country specific estimates of the corrective fuel tax. The discussion on how far retail fuel prices are from the level consistent with efficient taxation is beyond the scope of this paper (see Coady et al., 2015 for further discussions).

**Figure 3. Trends in Average Retail Gasoline Prices by Country Groups, January 2000–December 2014 (US dollars per liter)**




Source: IMF and authors' calculations

**When comparing prices across products, gasoline is typically more expensive than diesel—a consequence of differentiated taxation—but this varies widely across countries.** In Europe, lower excise tax on diesel contributes to the negative price differential relative to gasoline, while the opposite is true in the United States. However, the spread is also subject to seasonal factors, with high demand for heating oil during winters pushing diesel prices higher where fuel prices are driven by market forces. In developing economies, diesel is generally less taxed on the grounds that higher diesel prices would increase transportation cost and ultimately put pressure on food prices,[14] which will adversely affect the poor. The same rationale also explains the low price of kerosene, a product generally used by low-income households for lighting and cooking.[15] Overall, although there may be some differences in the refining cost of gasoline, diesel and kerosene, government taxation is the major factor accounting for the retail fuel price differences across countries.

**Looking at the country specific data, the wide range of retail fuel prices is striking, even more so between countries sharing common borders.** Large disparities in prices give rise to smuggling activities trying to take advantage of the price differentials. The consequence is rising subsidies in the countries with lower prices, and tax revenue loss for the countries into which fuels are smuggled. Smuggling also makes it difficult for destination countries to undertake subsidy reform as the latter would increase the price difference further and encourage more smuggling.

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[14] Diesel is also subject to lower tax as a way to subsidize electricity production in developing countries, and keep production cost low for firms to limit pass-through to consumer prices.

[15] The downside is that low kerosene price can encourage adulteration of diesel.

**Monthly price changes in retail fuel prices were sizeable in some cases, mainly as a result of freezing the price at an unsustainable level for an extended period or because of an exchange rate shock.** From 2010 to 2014, the largest single monthly price increase occurred in Iran in the context of the subsidy reform of December 2010, which led to the gasoline price increasing by 300 percent, albeit from a lower level (it went up to USD 0.39 per liter from USD 0.10 per liter). Notable price increases also include Haiti, Ghana, Indonesia, and Yemen. The lack of successful and durable reform of fuel pricing explains the recurrence of sudden large price increases in some of these countries (see Clements *et al.*, 2013).

**There were also episodes of large decline in retail fuel prices, reflecting pass-through of a sharp drop in international oil prices, and in a few cases a reform reversal.** Indeed, most of the large price declines occurred in 2008, coinciding with the decrease in international oil prices at the onset of the 2008/09 global financial crisis. However, there were also large price declines when governments backtracked on fuel price reform because of social unrest and opposition from interest groups

## III. Analysis of Pass-Through: How Have Countries Reacted to Changes in Oil Prices Over Time?

**Having presented the new dataset on retail fuel prices and the stylized facts, this section will examine the role of international oil price shocks in explaining the trends in retail fuel prices and the policy responses.** We first adopt a static approach to validate the findings from existing studies on pass-through estimates. For instance, Coady et al. (2010) provides estimates of pass-through coefficients for gasoline, diesel, and kerosene between end-2003 and mid-2008 for 155 countries. Also, Coady, Flamini and Sears (2016) reexamine diesel pass-through for a sample of developing economies between end-2004 and end-2014. Similarly, Kojima (2012) investigates the degree of pass-through for gasoline, diesel, kerosene, and LPG in a sample of 73 countries between January 2009 and January 2012. We focus the analysis on the period January 2005–December 2014, allowing us to document domestic fuel price responses to the sharp drop in international oil prices in 2014. Moreover, the use of monthly data allows us to carry out the pass-through analysis over specific episodes of oil price spells.

**After discussing the pass-through coefficients, we will turn to the key contribution of this paper by exploiting the richness of the new dataset to estimate the dynamic responses of retail fuel prices to international price shocks using impulse response functions.** With this approach, the paper delves into how retail fuel prices respond to international shocks within a certain time horizon (short and medium-term), how fast they adjust to them as well as the persistence of the shock, and whether retail fuel prices respond differently to positive and negative international oil price shocks. Finally, we will investigate the implications of using yearly averages instead of end-of-year retail fuel prices for the estimation of the fiscal cost of incomplete pass-through.

## A. Assessing Developments in Pass-Through: A Static Approach

**International oil prices have exhibited significant volatility in the past 10 years (Figure 4).** Analyzing this trend led us to identify five subperiods during 2005–14 characterized by different international oil price trends:

- *January 2005 to December 2006*: international oil prices increased gradually until their peak in July 2006, albeit with some volatility, before declining toward the end of the year.

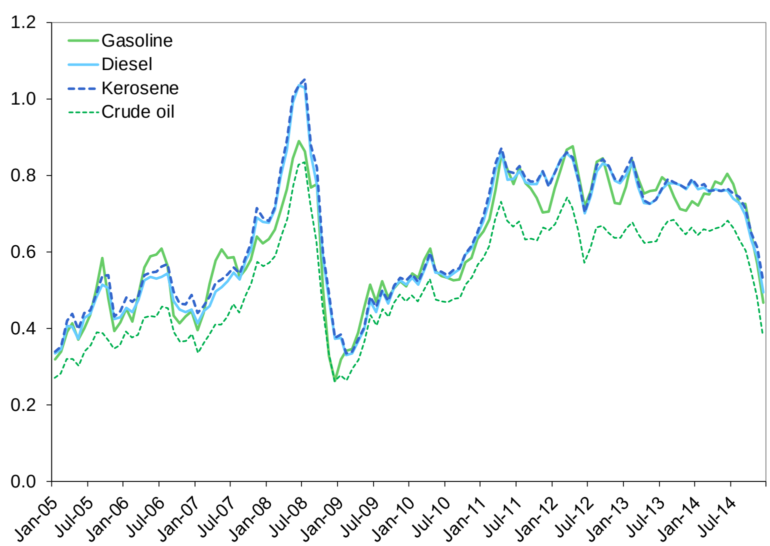
- *January 2007 to June 2008*: oil prices rose dramatically, culminating in the 2008 fuel price crisis.

- *July 2008 to February 2009*: this period featured a sharp and unanticipated decline in oil prices at the onset of the global financial crisis, reversing the increase in prices observed in the previous period.

- *March 2009 to June 2014*: oil prices rebounded in the first half of the period, and remained more or less stable thereafter.

- *July 2014 to December 2014*: oil prices declined by 40 percent, partly because of unexpected demand weakness in some major economies—in particular, emerging market economies, and oil supply factors, including the decision of the Organization of the Petroleum Exporting Countries (OPEC) to maintain current production levels despite the steady rise in production from non-OPEC producers, especially the United States (IMF, 2015).

**Figure 4. Trends in International Oil Prices, 2005–2016**
**(US dollars per liter)**




Source: US Energy Information Administration and IMF

**The pass-through coefficient is calculated as the absolute change in retail fuel prices divided by the absolute change in international oil prices, both expressed in US dollars.** The formula is as follows:

$$PT^{i} = 100 * \frac{P_t^i * e_t - P_{t-1}^i * e_{t-1}}{P_t^* - P_{t-1}^*} \qquad (1)$$

with PT the pass-through coefficient in percent
$P_t$ is the retail price in the local currency unit at period $t$
$P_t^*$ is the crude oil price at period $t$
$e_t$ is the exchange rate at period $t$ expressed in US dollars by unit of local currency
$i$ is an index for the fuel product considered[16]

**Assuming that other elements of the price structure such as transportation costs and margin are fairly stable, any changes in supply cost not reflected in the end-consumer prices are likely to be driven by changes in fuel tax, which is the main tool for governments to keep control on retail fuel prices when prices are not liberalized or when an automatic pricing mechanism is not in place.** For a positive change in international oil prices, a pass-through coefficient lower than 100 percent is an indication that net fuel tax has been reduced (a subsidy increase). Conversely, a pass-through coefficient of more than 100 percent implies a constant or higher net fuel tax.[17]

**Table 2 shows the median pass-through coefficients for different groups of countries in the five subperiods considered and for gasoline, diesel and kerosene.**[18] There is wide heterogeneity of pass-through coefficients across country groups, which tends to increase with income level. Not surprisingly, pass-through was the highest in advanced economies and emerging Europe, where prices are liberalized. The pass-through coefficients are consistently above 100 percent, reflecting a combination of higher taxes and the impact of ad valorem rates. Looking at the other tail of the distribution, MENA countries exhibit the lowest pass-through coefficients.[19]

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[16] Given the limited data on LPG prices, we restrict the analysis to gasoline, diesel and kerosene.

[17] However, the pass-through coefficient can exceed 100 percent even with no change in *tax policy* because of ad valorem tax. There is also a lag of transmission of international fuel prices to consumer prices reflecting fuel procurement processes, frequency of fuel imports, transport and difference in fuel quality. For further discussions, see Kojima (2012).

[18] LPG is excluded due to limited data.

[19] The high pass-through observed during January 2005–December 2006 should be interpreted with caution as the gradual increase in oil prices already started from early 2003, and this may reflect delayed pass-through or the fact that it is easier to pass though smaller international oil price increases. Also, oil prices were still relatively low, allowing governments to increase tax revenues; the efficiency and low collection cost of fuel taxation making it an attractive option to mobilize tax revenues in the short-term.

**In developing economies such as in Sub-Saharan Africa, Latin America, and Developing Asia, gasoline often had the highest pass-through, followed by diesel then kerosene, but the pattern is mixed in advanced economies and emerging Europe.** This is not surprising as in many developing countries, diesel and kerosene are regarded as sensitive products whose price increases would affect the poor, prompting governments to subsidize these products despite mounting evidence that fuel subsidies are poorly targeted,[20] burden public budgets and heighten fiscal risks.

**Table 2. Median Pass-Through Coefficients by Country Groups and Over Time**

| | Median Pass-Through Coefficients | | | | | |
|---|---|---|---|---|---|---|
| | Jan 2005-Dec 2006 | Jan 2007-Jun 2008 | Jul 2008-Feb 2009 | Mar 2009-Jun 2014 | Jul 2014-Dec 2014 | Average |
| **Gasoline median pass-through** | | | | | | |
| Advanced Economies | 138 | 159 | 146 | 168 | 121 | 146 |
| Commonwealth of Independent States | .. | .. | 37 | 58 | 0 | 32 |
| Developing Asia | 172 | 73 | 61 | 76 | 64 | 89 |
| Emerging Europe | .. | 153 | 136 | 167 | 132 | 147 |
| Latin America and the Caribbean | 136 | 93 | 86 | 102 | 58 | 95 |
| Middle East and North Africa | .. | 41 | 1 | 16 | 0 | 15 |
| Sub-Saharan Africa | 172 | 91 | 82 | 85 | 39 | 94 |
| All countries | 146 | 108 | 87 | 97 | 69 | 101 |
| **Diesel median pass-through** | | | | | | |
| Advanced Economies | 143 | 184 | 164 | 164 | 106 | 152 |
| Commonwealth of Independent States | .. | .. | 31 | 48 | 26 | 35 |
| Developing Asia | 187 | 78 | 61 | 57 | 47 | 86 |
| Emerging Europe | .. | 182 | 164 | 167 | 108 | 155 |
| Latin America and the Caribbean | 119 | 100 | 76 | 92 | 39 | 85 |
| Middle East and North Africa | .. | 33 | 1 | 13 | 0 | 12 |
| Sub-Saharan Africa | 170 | 108 | 58 | 58 | 39 | 86 |
| All countries | 155 | 125 | 93 | 82 | 56 | 102 |
| **Kerosene median pass-through** | | | | | | |
| Advanced Economies | .. | .. | .. | .. | .. | .. |
| Commonwealth of Independent States | .. | .. | .. | .. | .. | .. |
| Developing Asia | 141 | 54 | 27 | 44 | 44 | 62 |
| Emerging Europe | .. | .. | .. | .. | .. | .. |
| Latin America and the Caribbean | 150 | 107 | 92 | 84 | 40 | 95 |
| Middle East and North Africa | .. | 38 | 0 | 14 | 0 | 13 |
| Sub-Saharan Africa | 197 | 82 | 58 | 49 | 31 | 83 |
| All countries | 175 | 85 | 45 | 46 | 26 | 75 |

Note: Unbalanced samples
Source: Authors' calculations

[20] Coady, Flamini and Sears (2016) assess the distributional impact of fuel subsidy reform on household welfare in developing countries, and show that fuel subsidies are a costly approach to protecting the poor as higher income groups benefit the most from the subsidies (see also Arze del Granado, Coady and Gillingham, 2012).

**Consistent with the finding of Coady et al. (2010), the pass-through coefficients indicate that many countries failed to fully pass through the increase in international oil prices during the 2008 oil price crisis, resulting in sizeable fuel subsidies.** Pass-through to gasoline prices in sub-Sahara Africa and Latin America were comparable, respectively at 91 and 93 percent, while MENA countries recorded a very low pass-through of 41 percent in January 2007–June 2008. Pass-through was also weak in Developing Asia. In the subsequent period where oil prices fell sharply, pass-through coefficients were consistently lower than in the previous period, pointing to some asymmetry between rising and decreasing oil price spells, a hypothesis that will be more rigorously tested in the next section.

**The low pass-through during July 2014 to December 2014 is striking when compared to that of a similar period (July 2008 to February 2009) when oil prices also sharply declined.** Although there could be some lag in the transmission of international oil price changes to consumers, it is clear that retail fuel prices did not decline as quickly as they did in the second half of 2008. Taking the example of sub-Saharan Africa, the median pass-through was about half the level in 2008 for gasoline, and about 20 percentage points less than in 2008 for diesel. In Latin America, the median pass-through was about 30 to 50 percentage points lower than in 2008 depending on the fuel product considered. This suggests that despite recent progress in reforming fuel subsidies and fuel pricing, government price control is still pervasive in developing economies. Surprisingly, the pass-through also declined in advanced economies and emerging Europe, but the decline is more pronounced in developing countries. While it is unclear at this stage what explains the lower pass-through in richer countries, the motivation behind the low pass-through in developing economies where prices are still controlled, could be that the governments are taking advantage of low oil prices to build fiscal buffers or possibly recoup the loss of revenue when oil prices were high.

### B. Impulse Responses of Retail Fuel Price to International Oil Price Shocks Using Local Projections

**Although the static analysis is informative to give a broad idea on pass-through, it conceals the dynamic features of the pass-through.** As a result, to estimate the dynamic responses of retail fuel prices, we adopt an empirical framework relying on a univariate model accounting for the relationship between retail gasoline prices and crude oil prices, both expressed in US dollars.[21] The impulse responses are derived using the local projection approach developed by Jorda (2005). This approach consists in generating multistep predictions using direct forecasting models that are re-estimated for each forecast, and remains robust to misspecification given that the impulse responses can be defined without reference to the unknown data generating process (Jorda, 2005).

The baseline specification is as follows:

$$Gas_{it+h} = \gamma_q \sum_{q=0}^{p}\left(Gas_{it-q}\right) + \varphi_1 Crude_t + \delta_q \sum_{q=1}^{p}\left(Crude_{t-q}\right) + \tau + u_i + \varepsilon_{it} \quad \text{for } h=0,\dots,H \qquad (2)$$

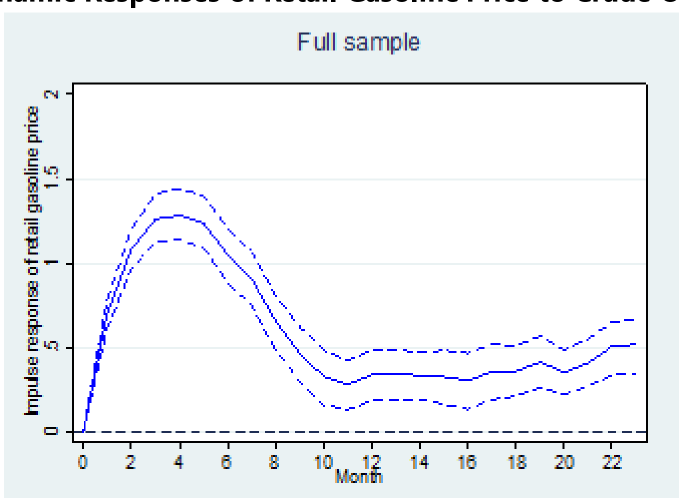
[21] We focus the analysis only on gasoline price to save space. The results are qualitatively similar for diesel.

Where *Gas* is the retail gasoline price, Crude is the average crude price calculated by the IMF,[22] $\tau$ is a time trend, *u* denotes country specific effects, $\varepsilon_{it}$ is the error term serially correlated or heteroscedastic, *h* is the number of horizons, and *p* is the number of lags.

**For each horizon h up to a maximum horizon H=23 (24 months), the coefficient of interest is $\varphi_1$ which denotes the response of the retail gasoline price to change in crude oil prices for different horizons.** The series $\varphi_1$ is estimated from a sequence of least squares regressions, with the 95 percent confidence interval obtained from a nonparametric block bootstrap with 1000 replications. Each equation includes 12 lags of retail and crude oil prices. We use the full country sample of the database, but restrict the period to January 2000-December 2014 due to data availability.

**Figure 5 shows the result for how a transitory shock in crude oil prices feeds through to retail gasoline price for the average country in the sample.** The magnitude of the impact suggests that a one cent per liter increase in crude oil prices translates into a 1.2 cent increase in gasoline prices per liter at a peak level (a pass-through of 120 percent), six months after the shock. This is not out of line with the average pass-through of about 100 percent estimated in the static analysis (Table 2). The speed of adjustment is quite sharp with a one-to-one parity being reached within the first three months. The impact decays gradually to less than 0.5 cent by the 10th month and remains persistent over time.[23]

**Figure 5. Dynamic Responses of Retail Gasoline Price to Crude Oil Price Shock**




Notes: The estimate is shown in solid line. Dotted lines are the 95 percent confidence intervals from a block bootstrap procedure with 1000 replications.
Source: Authors' calculations.

[22] It is the average of three petroleum spot prices (Dubai Fateh, UK Brent and West Texas Intermediate).

[23] We also estimate the impulse response functions using international gasoline price proxied by the New York Harbor gasoline price. The peak pass-through is comparable to that of crude oil prices.

**However, this result hides some heterogeneity across country groups (Figure 6).** Although the hump-shaped retail gasoline price response is observable in all country groups, the peak pass-through is larger in regions and income groups with more liberalized fuel price regimes. In advanced economies, the steep curve highlights the strong and almost instantaneous responses of retail gasoline prices. The pass-through coefficient overshoots to up to 200 percent within the first six months, before dropping quickly to about 50 percent in the medium term.[24] Put differently, a one cent increase in crude oil prices per liter translates into a two cent increase in the retail gasoline price at peak level. This is double the average estimate for emerging economies (one cent), and 50 percent larger than the average estimate for low-income countries (1.3 cents).[25]

**In Emerging Europe and sub-Saharan Africa, the adjustment is more gradual and the peak pass-through is lower than in advanced economies.** In other regions (MENA, Developing Asia, and Latin America), the retail gasoline price response is muted and slow. The peak pass-through in the MENA region is barely above 50 percent due to low fuel taxes (and hence high fuel subsidies) in the region and widespread price control, whereas in Developing Asia and Latin America, it reaches 100 percent, but could also be below that level judging by the wider confidence bands. Moreover, the pass-through is particularly short-lived in these regions as the medium-term impact is not statistically different from zero. As a result, the persistence of the shock observed in the overall sample seems to be driven by the advanced economies and sub-Saharan Africa. Different factors, although not tested in this paper, could be associated with a persistence of the shock. For instance, a lack of competition or the existence of monopolistic behaviors could explain that when oil prices reverse back after a positive shock, the transmission to retail prices takes more time. Also, this could be attributable to an opportunistic way for governments to increase fuel taxes (or reduce subsidies) when oil prices decline after a positive shock.

**The baseline model is constrained by the symmetry of effects, with responses to positive and negative shocks being mirror images of each other.** Yet, the question of whether the response of retail fuel price to a change in international oil prices is asymmetric or not has been extensively debated in the empirical literature (Borenstein, Cameron and Gilbert, 1997; Peltzman, 2000; Bachmeier and Griffin, 2003; and Radchenko, 2005). However, there is no consensus on the so-called "rocket and feather effect" whereby retail fuel prices rise rapidly in times of rising world oil prices and fall slowly when world prices come down. For instance, Borenstein, Cameron, and Gilbert (1997) find pervasive evidence of asymmetric response in U.S. gasoline markets, in sharp contrast with Bachmeier and Griffin (2003) who find no evidence. Similarly, Balke, Brown, and Yucel (1998) find only a small asymmetric relationship between crude oil prices and retail gasoline prices. Radchenko (2005) finds that the degree of asymmetry declines with increasing oil price volatility.

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[24] This compares with the average gasoline pass-through of about 150 percent for advanced economies estimated in the static analysis in Table 2.

[25] The unusual pattern of pass-through in Emerging Europe merits further investigation. Robustness checks with different time periods and exclusion of potential outliers do not alter this result.

**Figure 6. Dynamic Responses of Retail Gasoline Price to Crude Oil Price Shock, by Income and Regional Groups**


Note: Each panel includes, for the baseline model, the estimate (solid line) and the 95 percent confidence interval (dotted lines) from a block bootstrap procedure with 1000 replications.
Source: Authors' calculations.

**While most of these studies are country-specific and in particular focus on the US fuel market and other advanced economies in Europe, this paper adds to the literature by assessing the asymmetry in the effects in a large sample of advanced, emerging, and low-income countries.** The baseline specification is modified by splitting the variable on crude oil prices into two censored variables defined as follows:

$$Crude_t^+ = \begin{cases} Crude_{it} & if\ \Delta Crude_t > 0 \\ 0 & if\ \Delta Crude_t \leq 0 \end{cases} \tag{3}$$

$$Crude_t^- = \begin{cases} Crude_{it} & if\ \Delta Crude_t < 0 \\ 0 & if\ \Delta Crude_t \geq 0 \end{cases} \tag{4}$$

with $Crude_t$ being the price of crude oil in month $t$

**The relevant lags of the two new variables capturing crude oil prices in periods of negative and positive changes are also included in the specification.** The model is as follows:

$$Gas_{it+h} = \gamma_q \sum_{q=0}^{p} (Gas_{it-q}) + \alpha_1 Crude_t^+ + \beta_1 Crude_t^- + \delta_q \sum_{q=1}^{p} (Crude_{t-q}^+) + \theta_q \sum_{q=1}^{p} (Crude_{t-q}^-) + \tau + u_i + \varepsilon_{it} \quad \text{for } h=0,\ldots,H \tag{2}$$

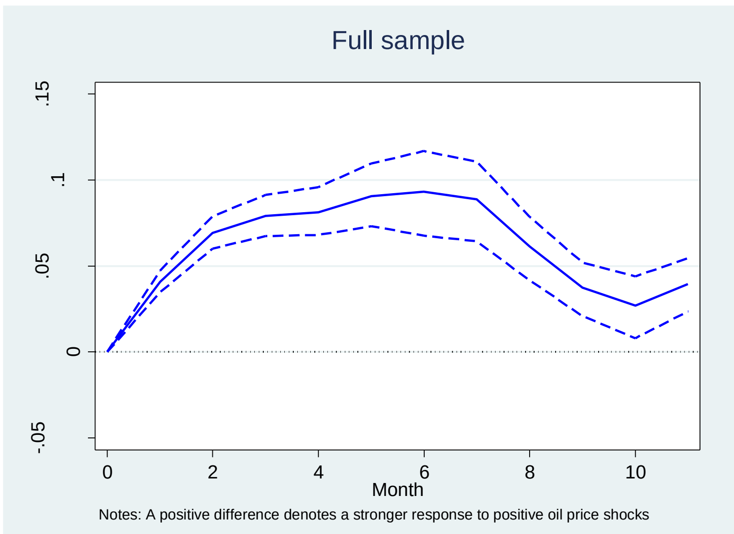
**Where *Gas* is the retail gasoline price, $Crude_t^+$ and $Crude_t^-$ capture respectively positive and negative oil price shocks, τ is a time trend, *u* denotes country specific effects, $\varepsilon_{it}$ is the error term serially correlated or heteroscedastic, *h* is the number of horizons, and *p* is the number of lags (12).**

**As for the baseline specification, we estimate for each horizon *h* up to a maximum of H=23 (24 months), the response to positive and negative shocks, respectively the series $\alpha_1$ and $\beta_1$, from a sequence of least squares regressions.** But, the coefficient of interest here is the difference between $\alpha_1$ and $\beta_1$, which we denote $\pi_1$. The series of coefficients $\pi_1$ is simultaneously estimated with equation 2, and the 95 percent confidence interval is computed from a nonparametric block bootstrap with 1000 replications. A positive and significant coefficient $\pi_1$ would imply that retail gasoline price tends to react more to positive oil price shocks than to negative ones.

**Figure 7 reports the series $\pi_1$ ($\alpha_1 - \beta_1$) which clearly points to an asymmetry between rising and falling international prices.** The response of retail gasoline prices to positive oil price shocks is faster than for negative shocks, and this explains why the difference between the two coefficients rises initially. At peak level (about 8 months after the shock), the pass-through for positive oil price shocks is about 10 percentage points larger than that of negative shocks, and then the gap starts to narrow as the pass-through of positive shocks phases out more rapidly.

**Looking at disaggregated country groups (Figure 8), we find evidence of asymmetry effects in advanced economies and low income countries, and to a less extent in emerging economies.** For instance, the peak pass-through for positive shocks is 20 percentage points higher than that of negative shocks in advanced economies compared to 10 percentage points in low-income countries and 5 percentage points for emerging economies. Moreover, the asymmetric response dies out within the first seven months in the sample of emerging economies. The pattern observed for emerging economies appears to be driven by countries in Developing Asia and Emerging Europe. The asymmetry is nearly inexistent in MENA countries, presumably because retail prices move little. While the magnitude of the asymmetric response in Latin America is comparable to that of Developing Asia, the former is more persistent. Reflecting the pattern in low-income countries, the asymmetric response in sub-Saharan Africa is not only larger, but also more persistent than in other developing country groups.

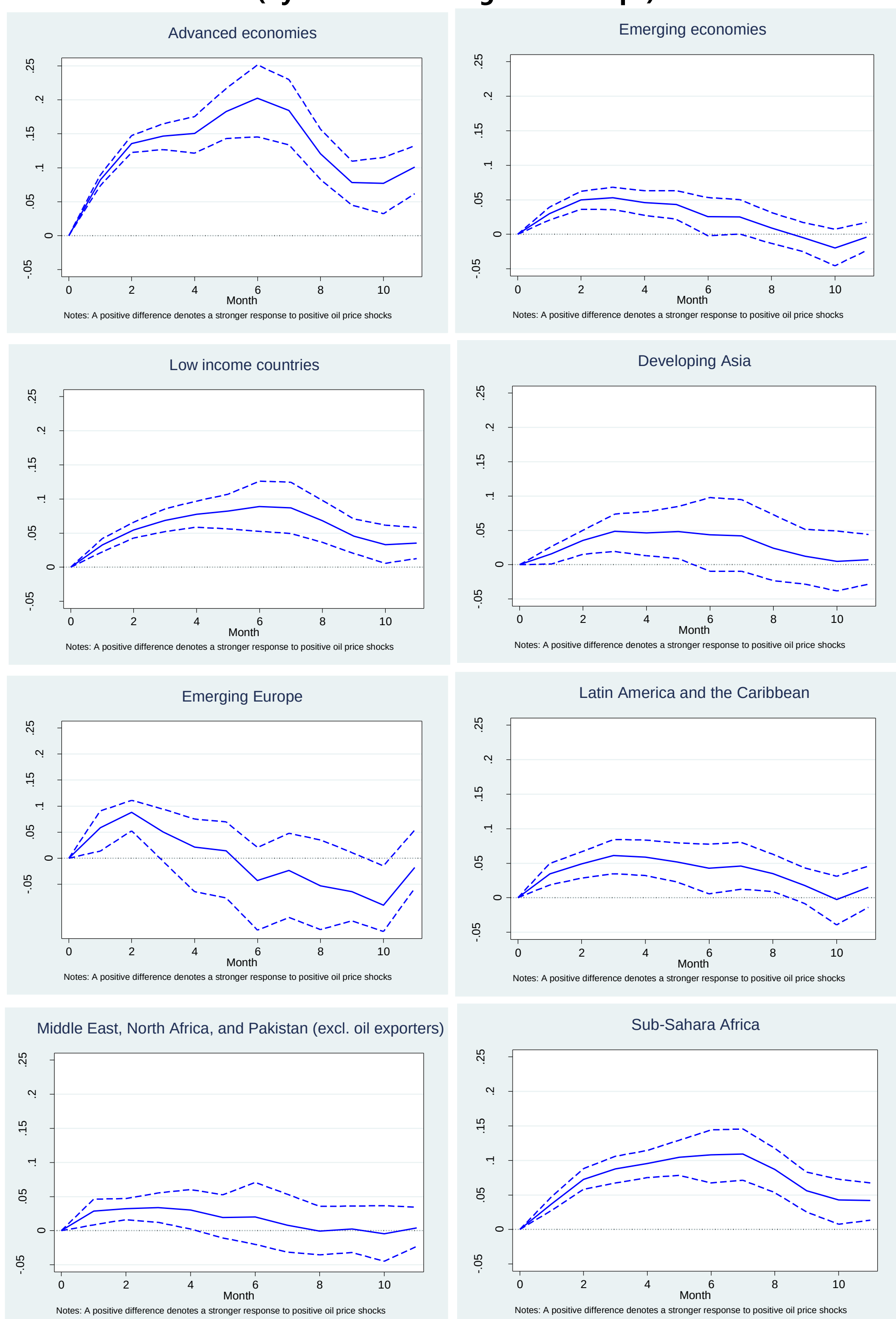
**Figure 7. Asymmetric Effects of Pass-Through of Crude Oil Price Shocks: Difference Between Positive and Negative Price Shocks (All Countries)**




Notes: The solid depicts the difference between the response of retail fuel prices to positive vs. negative shocks. Dotted lines are the 95 percent confidence interval from the bootstrap distribution.
Source: Authors' calculations.

**Reasons that have been put forward to explain the asymmetry include the lack of competition, production and inventory cost of adjustment, and search cost.** Borenstein, Cameron and Gilbert (1997) argue that an oligopolistic seller might choose to maintain a prior price in response to a negative cost shock until demand conditions force a change. Similarly, the authors emphasize that production lags and finite inventories of gasoline imply that negative shocks to the future optimal gasoline consumption path can be accommodated more quickly than positive shocks. On the other hand, according to Johnson (2002), the incentive to search for lower prices increases when prices rise, and conversely when prices are falling, the incentive to search for better prices declines. However, these theories are relevant for advanced economies, they may play a less significant role in developing economies. Indeed, another explanation that has attracted less attention (presumably because studies on asymmetry focus on advanced economies) is the government's role in fuel pricing in developing economies in particular. The tax windfall from lower pass-through eases fiscal constraints by helping reduce the fiscal deficit or create additional space for public expenditure.

**Figure 8. Asymmetric Effects of Pass-Through of Crude Oil Price Shocks: Difference Between Positive and Negative Price Shocks (by Income and Regional Groups)**




Notes: The solid line depicts the difference between the response of retail fuel prices to positive vs. negative shocks. Dotted lines are the 95 percent confidence interval from the bootstrap distribution.
Source: Authors' calculations.

### C. Fiscal Cost of Incomplete Pass-Through

**Previous studies (e.g. Coady et al., 2010) rely on snapshot surveys of end-of-period (or year) retail prices to estimate the fiscal cost of incomplete pass-through of international oil price changes.** However, retail prices do change and if the end-of-period prices deviate significantly from the average prices during the same period, this will affect the size of the estimated fiscal costs. For instance, assuming that international oil prices increase and retail price partially catch up, the observed end-of-period prices would be higher than the average prices, leading to an underestimation of the true fiscal cost of incomplete pass-through.

**We exploit the high frequency data to assess how significant the bias is and under which conditions.** To do so, the fiscal cost of fuel subsidies is estimated using the yearly average retail prices and then is compared with the estimates based on retail prices as of December of each year during 2005-13. Consistent with Coady et al. (2010), the benchmark price for net oil importers is set at the international U.S. dollar price for the relevant product[26] adjusted by $0.20 per liter to allow for the cost of shipping the product to the country and to cover the distribution and retailing costs within the country. For net oil exporters, the benchmark price is simply the international U.S. dollar price. Petroleum product consumption levels used to calculate subsidies are provided by the International Energy Agency (IEA), and nominal GDP data are extracted from the International Financial Statistics.

**The results reveal that there are significant differences between the estimates of the fiscal cost of incomplete pass-through using the end-of-year or the average retail prices.** In most cases, the use of the end-of-year retail prices underestimate the true fiscal cost of incomplete pass-through. The gap can be quite large as it peaked at an average of 1.4 percent of GDP in 2008, a year marked by the oil price crisis (Figure 9). Among fuel products, diesel is the largest contributor, which is not surprising, given that it is typically heavily subsidized in many countries. As expected, the underestimation of the fiscal cost tends to be, on average, larger in periods of large and sharp increases in international oil prices (the correlation coefficient is 0.30), suggesting that the fiscal cost of incomplete pass-through using end-of year retail prices is a good approximation of the real fiscal cost of fuel subsidies only in years where changes in crude oil prices are relatively modest and less volatile.

**There are also regional disparities with the underestimation of the fiscal cost in 2008 being the largest in the MENA region (Figure 10).** Indeed, crude oil price collapsed to USD42 per barrel in December 2008, after picking up to above USD130 per barrel in June-July. The resulting effect is a lower price gap (smaller subsidies) in MENA countries at the end of the year 2008, even for countries that did not increase retail fuel prices at the height of the crisis. Obviously, the average price gap, and hence the fiscal cost of lower pass-through, was much higher given the peak in crude oil price mid-year.

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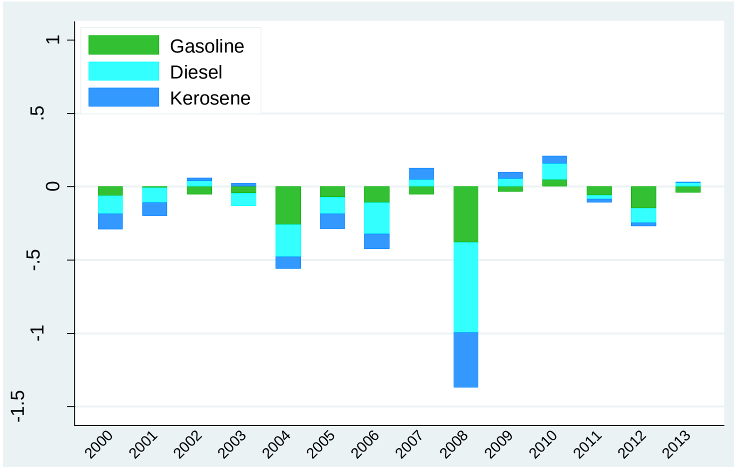
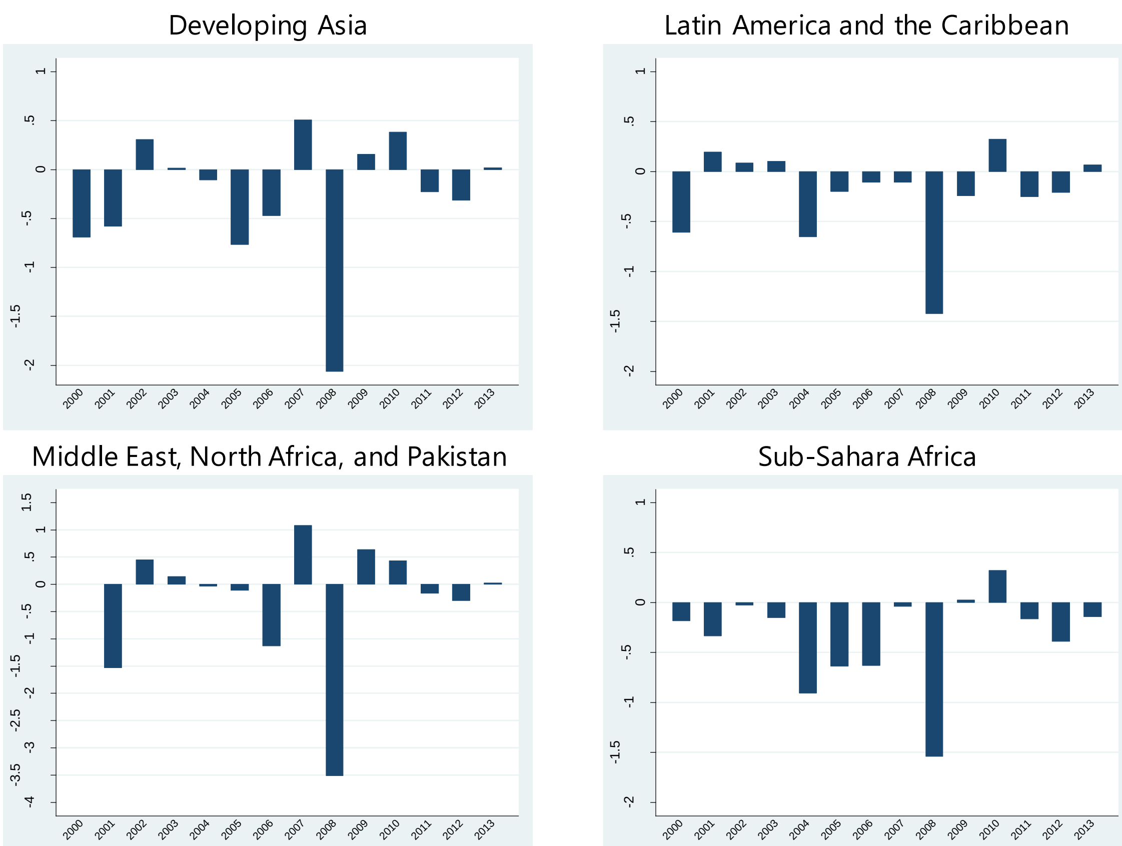
[26] We consider gasoline, diesel, and kerosene.

**Figure 9. Discrepancy Between the Fiscal Cost of Incomplete Pass-Through at the Average and End-of-Year Retail Fuel Prices, 2000–2013**




Notes: A negative figure implies that the fiscal cost of incomplete pass-through at end-of-period fuel price underestimates the true fiscal cost of incomplete pass-through calculated at the average fuel price.

**Figure 10. Discrepancy Between the Fiscal Cost of Incomplete Pass-Through at the Average and End-of-Year Retail Fuel Prices in Selected Regions, 2000–2013**




Notes: A negative figure implies that the fiscal cost of incomplete pass-through at end-of-period fuel price underestimates the true fiscal cost of incomplete pass-through calculated at the average fuel price)
Source: Authors' calculations.

**The opposite occurred in 2007 when the international oil price was in rising trend. MENA countries in most cases maintained retail fuel prices constant, leading to a higher price gap (larger subsidies) at end-2007.** However, because the price gap was smaller at the beginning of the year 2007 and grew progressively, the price gap at end-2007 was bigger than the average price gap. As a result, the fiscal cost of incomplete pass-through using the end-of-year overestimate the true cost of fuel subsidies.

**The magnitude of the discrepancies illustrates the usefulness of intra-year data on retail fuel prices to closely track changes in fuel pricing policy and provide a more accurate picture of the fiscal cost of subsidies.**

## IV. CONCLUSION

**This paper examines the transmission of oil price shocks to retail fuel prices building on a novel database on monthly retail fuel prices in 162 countries worldwide.** The new database is more comprehensive than existing ones in terms of data frequency, time horizon, country sample, and diversity of fuel products.

**Interesting results emerge from the static analysis of pass-through.** Not surprisingly, and in line with findings from previous studies, countries in the MENA region tend to have the lowest pass-through coefficients mirroring large fuel subsidies (mainly in oil exporting countries), in sharp contrast with advanced economies and emerging Europe, the regions with the highest pass-through. The pass-through coefficient also varies by products, being in most cases higher for gasoline than for diesel and kerosene which are generally more subsidized in developing countries on the grounds that an increase in their prices will adversely affect the poor.

**Our results also offer new insights, notably on the pass-through of the 2014 drop in oil prices which has been relatively weak at end-2014, mainly in developing countries, probably because governments saw an opportunity to reduce fuel subsidies and shore up public finances.** However, this suggests that despite recent progress in reforming fuel subsidies and pricing, government control of fuel prices remains a widespread phenomenon.

**Further, looking at the pass-through coefficients in different periods, data point to a price asymmetry with the pass-through being higher when oil prices increase than when oil prices fall.** The static analysis of pass-through is supplemented by the estimation of impulse response functions, which would not have been feasible without the newly compiled high frequency data on retail fuel prices. The impulse response functions using Jorda (2005)'s local projection approach uncover the dynamic nature of the pass-through. The results suggest that on average a one cent increase in crude oil prices per liter translates into a 1.2 cent increase in retail gasoline price per liter (a pass-through level of 120 percent) at peak level within six months after the shocks. However, the peak pass-through varies across income groups and regions, being the lowest in MENA countries and the highest in advanced economies. The pass-through then declines over the medium-term, with some persistence observed in advanced economies and sub-Saharan Africa. The impulse response functions also highlight the asymmetric behavior of retail gasoline prices whereby the response to positive price shocks is faster and larger than that of negative price shocks.

**This paper also re-estimates the fiscal cost of incomplete pass-through using the average retail fuel prices and finds out that results of previous studies using the end-of-period retail prices often underestimate the true fiscal cost by a significant margin**, in particular during periods of large changes and volatile oil prices.

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## Appendix 1. An Overview of Existing Databases on Retail Fuel Prices

**Efforts have been made to compile cross-country data on retail fuel prices.** The most widely used sources include the GIZ, the European Commission (EC), the International Energy Agency (IEA), the UN Economic Commission for Latin America and the Caribbean (ECLAC), and more recently Bloomberg. In addition, there are studies that carried out a survey of retail fuel prices for specific research purposes (for instance; Coady et *al.*, 2010; Coady et *al.*, 2015; Clements *et al.*, 2013; Kojima, 2013).

**Notwithstanding the usefulness of available datasets, they are limited in a number of aspects.** Institutional databases such as the GIZ have large country coverage and a fair time dimension, but has a low frequency (annual). This limits the breadth of analyses that look at dynamics within the year and their macroeconomic effects.[27] This is crucial in light of the observed short-term volatility in fuel prices, and the policy responses to them. In addition, the GIZ database is limited in terms of product coverage as it does not compile data on kerosene and LPG, both products still accounting for a significant share of household energy consumption in developing economies. While other institutional databases may offer higher frequency data, the coverage tends to be restricted to certain countries in specific regions (EC and ECLAC databases) or certain income groups (IEA and Bloomberg databases). Datasets from specific studies do not often cover a sufficiently long time horizon, and can also be limited either in terms of country coverage or data frequency.

**The following summarizes the features of existing institutional databases in terms of country coverage, time dimension, and data frequency:[28]**

- *GIZ database*.[29] One of the flagship publications of the GIZ is the international fuel prices report published every other year. The 2012/13 report provides an overview of retail gasoline and diesel prices in about 170 countries based on a snapshot survey of prices conducted in November of every other year, starting in the 1990s. Using the world crude oil price, the retail prices in the United States and in Luxembourg as benchmarks, the report categorizes countries in four main groups: high fuel subsidies, fuel subsidies, fuel taxation, and high fuel taxation.[30] The report is supplemented by country factsheets (for about 130 countries) with information on fuel price trends, fuel price policies,

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[27] For instance, high frequency data are needed to gauge the short-term response of consumer prices to changes in retail prices (see Abdallah and Kpodar, 2015).

[28] Description based on the 2016 version of these databases.

[29] The World Development Indicators published by the World Bank report GIZ data on retail fuel prices.

[30] Countries with high fuel subsidies are those where retail prices are below the price of crude oil on the world market. For countries in the fuel subsidies category, retail prices are above international crude oil prices, but below retail prices in the US. When retail prices are above that in the US, but below prices in Luxembourg (the lowest in the EU in November 2012), the country is classified in the fuel taxation category. Countries with high taxation are those where retail fuel prices are above the levels in Luxembourg.

composition of prices, and assessment of the nature of the pricing mechanism (ad hoc pricing or liberalized prices).

- *IEA database*. It covers 33 OECD member countries with quarterly data from 1978 through 2014 on end-consumer prices for various energy products, including gasoline and diesel.[31] The database also compiles prices for industries and provides data on import costs and taxes on energy products. In addition, for a small subset of countries,[32] the IEA releases monthly data (starting from 2005) on gasoline, diesel, heating oil, and fuel oil prices and their applicable taxes.

- *EC database*. With the aim to improve transparency of fuel prices in the 28 countries of the European Union (EU), the EC has published weekly retail fuel prices and associated taxes with the breakdown in different taxes (VAT, excise, other indirect taxes) since 2009.

- *ECLAC database*. Covering 11 countries in Latin America, this database compiles information on prices for various petroleum products (regular and premium gasoline, diesel, kerosene, fuel oil, LPG), as well as the composition of prices (import prices, taxes, gross margin) on an annual basis since 2001. Interestingly, the database also provides information on government revenue from taxation of fuel products.

- *Bloomberg database*. It compiles quarterly gasoline prices for 61 countries, mainly advanced and emerging countries, since 2013 and provides rankings by average price, affordability (measured by the average day's wages needed to buy a gallon/liter of fuel), and the expenditure share of gasoline spending (portion of annual income spent on total gas purchases).

**Aside from these institutional databases, few studies have gathered retail fuel prices data to address specific research questions.** For instance, Coady et *al.* (2010) compile a database on end-of-period retail fuel prices (gasoline, diesel, kerosene) from 2003 to 2008 for a large number of countries (186) to analyze pass-through levels and estimate the magnitude and trends in fuel subsidies.[33] Coady et al. (2010) find that petroleum subsidies had increased significantly during the period considered as many countries failed to fully pass through the sharp increase in international oil price in 2007 and early 2008. Tax subsidies accounted for the bulk of fuel subsidies, reflecting suboptimal taxation. Coady, Flamini and Sears (2016) extend the data from Coady et al. (2010) to end-2014. Clements *et al.* (2013) provide an update of fuel subsidy estimates for 176 countries in 2011, while extending the analysis to other energy products such as natural gas, coal, and electricity. In addition, the study discusses the macroeconomic consequences of energy subsidies and identifies key ingredients for successful subsidy reforms, drawing on insights from 22 country case studies.

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[31] The IEA used to compile data quarterly energy prices and taxes for selected non-OECD countries, but the publication has been discontinued.

[32] France, Germany, Italy, Spain, UK, Japan, Canada and the United States.

[33] See also Baig *et al.* (2007) for a similar study for 2003–06, but with a smaller sample (51 countries).

**Kojima (2013) analyses petroleum product pricing in 65 developing countries, building on a survey of end-user prices for gasoline, diesel, and kerosene in July 2012 and pass-through coefficient estimates in January 2009 to July 2012.** The author documents various price control mechanisms (e.g. retail price ceilings, retail or wholesale price control) and price adjustment mechanisms (ad hoc price adjustments, automatic pricing mechanisms, price smoothing, fully-liberalized prices), and discusses mitigating responses to reduce vulnerability to high and volatile oil prices through energy efficiency improvement, energy diversification, and efforts to lower fuel supply costs.[34] More recently, Ross, Hazlett and Mahdavi (2015) compiles monthly gasoline price data for 157 countries to assess the degree to which a country has market-based prices.

[34] On a smaller sample (48 countries), Kojima (2009a) also looks at a snapshot of retail fuel prices of four petroleum products (gasoline, diesel, kerosene, LPG) and examines the degree of pass-through to consumers of increases in world gasoline and diesel prices since January 2004. Similarly, Kojima (2009b) extends the data to January 2009 to investigate how countries responded to the large decline in oil prices from September 2008.

## Appendix 2. Composition of Country Groups (IMF World Economic Outlook Classification)

**Advanced Economies:** Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Malta, Netherlands, New Zealand, Norway, Portugal, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Taiwan Province of China, United Kingdom, and United States.

**Emerging Economies:** Algeria, Angola, Argentina, Armenia, Azerbaijan, Bahrain, Belarus, Botswana, Brazil, Brunei Darussalam, Bulgaria, Chile, China, Colombia, Costa Rica, Croatia, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Fiji, Gabon, Georgia, Guatemala, Hungary, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Kuwait, Latvia, Lebanon, Libya, Lithuania, Malaysia, Mauritius, Mexico, Morocco, Namibia, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Qatar, Romania, Russia, Saudi Arabia, Serbia, Seychelles, South Africa, Sri Lanka, Swaziland, Syria, Thailand, Trinidad and Tobago, Tunisia, Turkey Turkmenistan, United Arab Emirates, Uruguay, and Venezuela.

**Low Income Developing Countries (LIDC):** Afghanistan, Bangladesh, Benin, Bolivia, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Republic of, Cote d'Ivoire, Democratic Republic of the Congo, Djibouti, Ethiopia, Gambia, The, Ghana, Grenada, Guinea, Guinea-Bissau, Haiti, Honduras, Kenya, Kiribati, Kyrgyz Republic, Lao P.D.R., Lesotho, Liberia, Madagascar, Malawi, Maldives, Mali, Mauritania, Moldova, Mongolia, Mozambique, Myanmar, Nepal, Nicaragua, Niger, Nigeria, Papua New Guinea, Rwanda, Samoa, Sao Tome and Principe, Senegal, Sierra Leone, Sudan, Tajikistan, Tanzania, Timor-Leste, Dem. Rep. of, Togo, Uganda, Uzbekistan, Vietnam, West Bank and Gaza, Yemen, Zambia, and Zimbabwe.

**Commonwealth of Independent States:** Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Russia, Turkmenistan, Kyrgyz Republic, Moldova, Tajikistan, and Uzbekistan.

**Developing Asia:** Brunei Darussalam, China, Fiji, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, Bangladesh, Kiribati, Lao P.D.R., Maldives, Mongolia, Myanmar, Nepal, Papua New Guinea, Samoa, Timor-Leste, Dem. Rep. of, and Vietnam.

**Latin America and the Caribbean:** Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Jamaica, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, Venezuela, Bolivia, Grenada, Haiti, Honduras, and Nicaragua.

**Middle East, North Africa, and Pakistan:** Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, Afghanistan, Djibouti, Mauritania, Sudan, West Bank and Gaza, and Yemen.

**Sub-Sahara Africa:** Angola, Botswana, Equatorial Guinea, Gabon, Mauritius, Namibia, Seychelles, South Africa, Swaziland, Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Republic of, Cote d'Ivoire, Democratic Republic of the Congo, Ethiopia, Gambia, The, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Tanzania, Togo, Uganda, Zambia, and Zimbabwe.