WP/11/102

IMF Working Paper

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INTERNATIONAL MONETARY FUND

 WP/11/102

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Oil Spill(over)s: Linkages in Petroleum Product Pricing Policies in West African Countries[1]

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Authorized for distribution by Peter Allum

May 2011

Abstract

This paper addresses a number of issues regarding petroleum product pricing in Western Africa emphasizing international spillovers. We use panel unit root rests and long-run modeling based on vector error correction models to assess links and convergence in petroleum product prices across countries. Our results indicate that in general over the long-run there is convergence in prices across the countries. The estimation results for gasoline and diesel prices suggest the presence of long-run links between retail prices among the different country groupings with long-run multipliers ranging from 11 to -6.66. The speed of Adjustment to equilibrium varies significantly according to the country groupings considered. In contrast, the econometric results for kerosene prices not only indicate a weaker link between prices across countries, but also a much slower adjustment to equilibrium. In light of these important spillovers, the need to better coordinate pricing and tax policies towards petroleum products at the regional level becomes apparent.

JEL Classification Numbers: O10, O55, F42

Keywords: Oil Prices, International Spillovers, Smuggling, West Africa.

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[1] We would like to thank Peter Allum, David Coady, Luc Eyraud, Sean Nolan and participants of the IMF's African Department External Sector Network seminar series for useful comments. We are also grateful to our desk economist colleagues in the IMF's African department who shared their data and country specific information with us. All the remaining errors are ours.

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I. INTRODUCTION

Several African countries have administrative pricing policies for petroleum products with important and at times unintended economic and fiscal side-effects. Frequently, these policies aim to reduce the volatility of domestic retail prices and to mitigate the impact of higher prices on the poor (Bacon, R. & Kojima, M., 2008). With the large international oil price increases observed in the period from the beginning of 2007 to mid-2008, policy makers in a large number of countries chose not to pass-through the increase in world prices to domestic prices at the pump. Consequently, during this period governments in countries where the private sector is involved in oil distribution incurred explicit or quasi-fiscal implicit liabilities to these distributors, as their margins were usually guaranteed by the price setting policies.

Furthermore, pricing policies for these products might generate unintended international spillovers and distortions, as price differentials across countries could (at least partly) be driven by administrative policies rather than market forces. These international links have been frequently discussed informally in the policy dialogue with authorities, in particular the issue of smuggling, unregistered trade and other arbitrage strategies to exploit price differentials that are considered to be important constraints to the independence of national price setting policies. Ballong (2010), for example, states that the smuggling of petroleum products from Nigeria to Benin implies a cost of over 23 million Euros per year in fiscal revenue losses to Benin's government. The Ghana-Togo frontier near Kpassa in the Volta Region has also experienced strong smuggling activity, leading to actions by the police and community watch groups that was documented in recent press reports[2].

This paper addresses a number of issues regarding petroleum product pricing in a group of Western African countries with a particular emphasis on international spillovers stemming from differences in pricing policies and (lack of) coordination. We use panel unit root rests and long-run modeling based on vector error correction models to assess links and convergence in petroleum product prices across countries.

The paper is divided as follows. Section II presents on overview of the institutional arrangements and policies regarding petroleum product prices in Western Africa and selected examples elsewhere in the World. Subsequently, Section III analyzes the linkages between retail prices (prices at the pump) for different petroleum products in the countries in the sub-region and assesses whether there has been convergence over time. In this section, we also estimate the size of the spillovers directly by using vector error-correction models of

[2] On March 12, 2010 the Ghana News Agency reported that: "A joint police task force and the Kpassa Community Watch Committee on Thursday impounded two unlicensed motor bikes and quantities of fuel in jerry cans abandoned by fuel smugglers after a hot chase. Mr Douglas Kumah, Nkwanta District Police Commander who briefed the GNA, said members of the Watch Committee sought the assistance of the police to clamp down on a smuggling gang along the Ghana-Togo frontier near Kpassa in the Volta Region. He said in one of their operations, the team encountered four unlicensed motor bikes carrying 30 litters each of fuel bound for Sarakawa in neighboring Togo. He said in the ensuing chase, two of the riders abandoned their bikes and fled into the forest while two others escaped with the fuel they were carrying."

petroleum prices to analyze long-run equilibrium relationships among prices in different Western African countries. Finally, in Section IV, we draw domestic and regional policy recommendations from the results obtained in this analysis and point towards directions where further analytical work is required.

II. Cross-Country Experiences on Petroleum Pricing Policies

This section presents on overview of the institutional arrangements regarding petroleum product prices in Western Africa and selected examples elsewhere in the World. The international experience suggests that the most sustainable policies (in terms of mitigating fiscal risks) for domestic pricing of petroleum products are either full liberalization or transparent and simple automatic adjustment of administered prices (Coady and others, 2010). In fact, a number of sub-Saharan African countries currently have a liberalized regime for setting domestic petroleum prices including, Kenya, Tanzania and Uganda. In general, a pre-requisite for a successful liberalization of domestic prices is to strengthen regulatory frameworks so as to inhibit anti-competitive behavior that would be harmful to consumers.

South Africa has a transparent automatic adjustment mechanism based on import parity and cost recovery profit margins regulated by the Department of Minerals and Energy. The price structure of petroleum products is published regularly on government websites. This mechanism is widely considered to have functioned well over the years (see Baig and others, 2007) and could constitute an example of a successful framework upon which to base reform.

Especially since the oil price shock starting in mid-2007, many countries that had automatic pricing schemes in principle (such as Benin, Burkina Faso, Côte d'Ivoire, Ghana, Niger, Sierra Leone, and Togo in West Africa, as well as Cameroon and Ethiopia outside the region) suspended the full operation of their schemes to insulate domestic prices (see the last panel of Figure 1). This suspension constituted an implicit subsidy that was usually costly, poorly targeted, opaque and unbudgeted (more on this below)[3]. However, others such as South Africa continued to apply their automatic mechanisms. The factors determining whether a country applies an automatic mechanism are not clear-cut.[4] Two possible factors suggested by the data are that countries with lower per capita income and/or low inflation (especially WAEMU) prefer lower volatility in petroleum product prices, but neither factor appears determinate (e.g., the poorest country in the region, Niger, displayed above average volatility).

It is also interesting to note that most countries that adopt ad hoc adjustment mechanisms, supposedly to increase the smoothing of international prices, did not experience lower volatility in prices, as measured by the coefficient of variation, in the period from January 2006 to October 2010 (see the first three panels of Figure 1). Benin, Niger, and Côte d'Ivoire,

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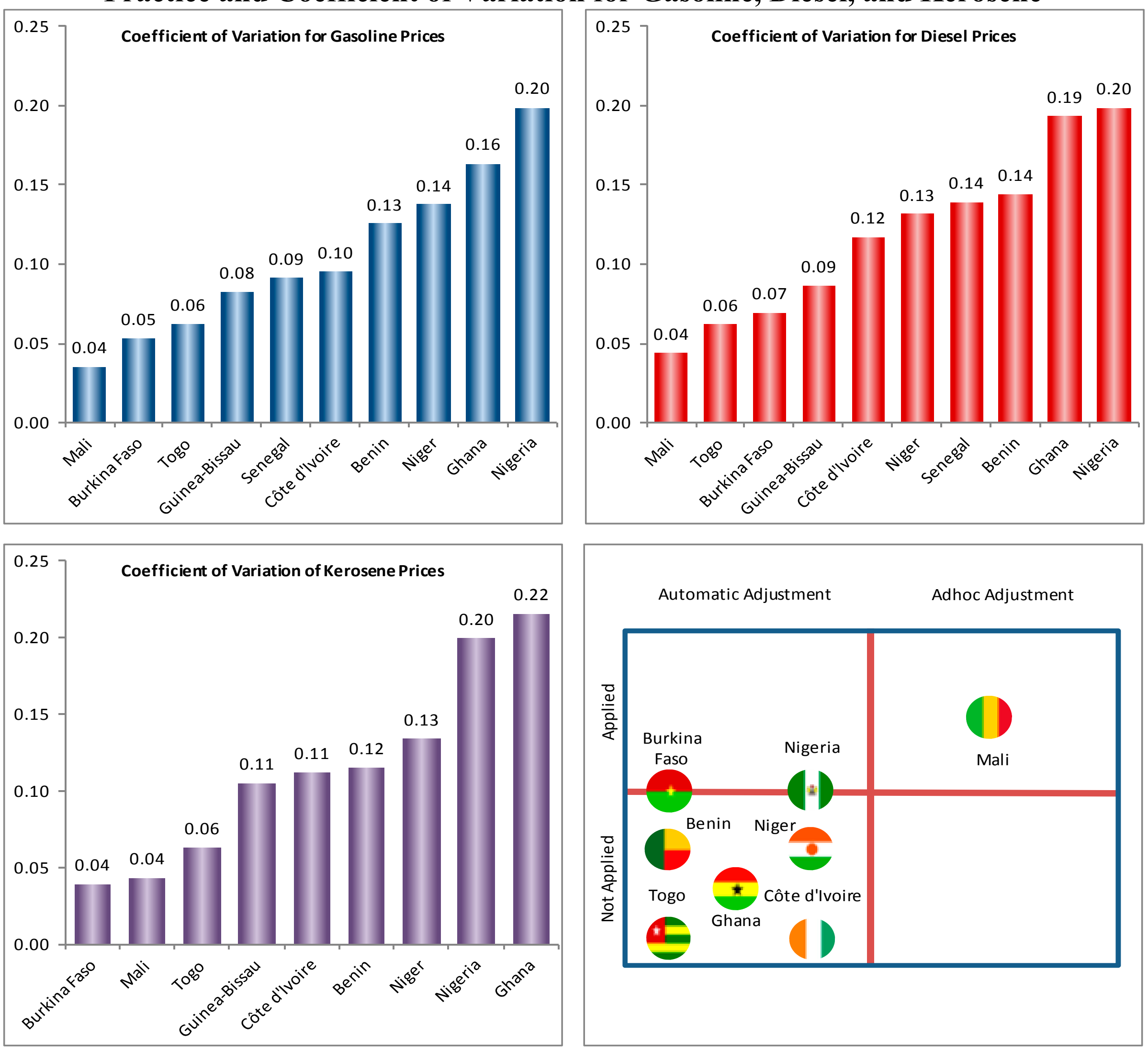
[3] For example, the fiscal cost in Togo for 2007-08 was between 0.7-2.0 percent of GDP.

[4] This issue may merit further investigation. Addressing concerns over price volatility can inform mitigating policy measures, such as automatic smoothing mechanisms that balance volatility and fiscal risks.

countries where automatic adjustment mechanisms have not been applied consistently, had the most volatile prices in the region for the three types of products considered.

Figure 1. West African Petroleum Product Pricing Mechanisms in Principle and in Practice and Coefficient of Variation for Gasoline, Diesel, and Kerosene



Source: Authors estimates and IMF country desks.

In practice there is little difference between an automatic adjustment mechanism that is not applied and a policy of ad-hoc adjustments in prices. The reluctance of governments to fully pass through increases in international prices can frequently be attributed to political economy considerations. In fact, more affluent sectors of the population and the urban middle class, which tend to be politically vocal groups, benefit most from the implicit or explicit subsidies to retail prices of petroleum products (more on estimates of the size of these subsidies below). Another prominent source of concern is the impact of increases in fuel prices on the real incomes of the poor. Nevertheless, the available evidence suggests that subsidies to petroleum product prices tend to be regressive (Coady, D., and others, 2010).

In this context, the governance structure of the institutions in charge of implementing the price formula is also an important element of the pricing policy. The pricing formula should be insulated from political influence, perhaps by delegating its implementation to an independent body, transparently organized, that includes representatives from the different industry stakeholders (importers, distributors, transporters, etc.) and with appropriate disclosure to the public. This should help to reinforce the public's understanding that price changes are determined by changes in international prices.

Taxation levels for petroleum products differ across countries in the region, reflecting different policy approaches to pricing and government revenue needs. Retail prices are usually derived from formulas based on import costs, storage and distribution margins, and different types of taxes (excise, VAT, others). Typically, kerosene is less heavily taxed for social reasons. Taxes on petroleum products can be a significant source of fiscal revenue, as indicated in Table 1.

Table 1. Petroleum Product Related Tax Revenue
(Percent of GDP)

	2008	2009	2010	Source of taxation
Benin	0.1	0.2	0.3	Only excises and import duties
Burkina Faso	0.7	0.7	0.7	Excises, import duties, and VAT
Côte d'Ivoire	0.9	1.7	1.8	Excises, import duties, and VAT
Ghana	1.3	0.8	0.6	Excluding VAT
Guinea Bissau	0.6	0.8	0.7	Excises, import duties, and VAT
Mali	0.9	0.5	0.5	Only excises
Niger	0.8	0.9	0.9	Only import duties
Senegal	3.3	3.0	2.8	Excises, import duties, and VAT
Togo	n.a.	n.a.	n.a.	

Source: Authors estimates based on information provided by country authorities.

As we alluded to previously in this section, the partial pass-through of international price movements constitutes an implicit subsidy that is usually costly and poorly targeted. Although most countries in the region do not include direct subsidies to petroleum products in their pricing formulas, the non-adjustment of retail prices to reflect increases in prices in international markets constitutes a large and often unbudgeted "implicit" subsidy to the consumers of petroleum products. In addition, the non-application of automatic mechanisms increases the volatility of net fiscal revenues linked to these products.[5]

[5]Net fiscal revenues derived from the price structure for petroleum products typically include ad valorem taxes such custom duties and VAT, other specific taxes (excise for example), and direct subsidies. In many cases, these different components of net taxes are modified such that increases in international prices are not fully passed through to consumers. Typically, changes in excises are one key instrument to smooth domestic fuel prices. For example, Niger increased subsidies and decreased excise taxes to mitigate the increase in price of imported gasoline between 2005 and 2008.

Following the methodology proposed by Coady, D., and others. (2010) we calculated tax inclusive implicit subsidies to petroleum products for the countries considered in this paper. Our estimates using data on consumption of petroleum products[6] are presented in Table 2 and suggest that these implicit subsidies vary by type of product and country and can reach significant amounts (up to 3.2 percent of GDP during the oil price shock in 2008). While diesel and kerosene prices tend to be implicitly subsidized in most countries, this is not the case for gasoline prices. For example, estimates show gasoline subsidies ranging from 2.4 percent of GDP to -0.8 percent of GDP[7], depending on the country and year. Kerosene is implicitly subsidized in all countries considered, with subsidies ranging from 3.2 percent of GDP to 0.02 percent.

Table 2. Tax Inclusive Implicit Subsidies
(Percent of GDP)

	2008	**2009**	**2010**
Gasoline	1.30	1.64	1.34
Range	*(-0.78,1.85)*	*(-0.59,2.35)*	*(-0.52,1.78)*
Diesel	0.36	0.27	0.26
Range	*(-1.46,1.34)*	*(-0.63, 1.58)*	*(-0.31, 1.24)*
Kerosene	0.21	0.18	0.14
Range	*(0.02, 3.20)*	*(0.02,1.31)*	*(0.03, 1.14)*

Source: Authors estimates based on information provided by country authorities. Estimates of tax-inclusive, implicit subsidies are based on the methodology proposed by Coady and others, 2010, assuming a benchmark tax rate of US$ 0.40 per liter. A positive number in the table implies a subsidy; a negative number implies that actual tax rates are above the assumed benchmark rate.

[6] Data from the International Energy Agency (IEA) includes consumption of petroleum products by households and enterprises. 2008 is the latest year for which information was available for a large set of countries considered here. Consumption in 2009 and 2010 was inferred using real GDP growth rates for individual countries.

[7] In this case, the estimates imply that taxation is actually above benchmark levels.

III. Linkages and Convergence in Petroleum Product Prices in West Africa

This section borrows from the empirical literature on the long-run behavior of real exchange rates (see for example, Bergin, Glick and Wu, 2009) and uses techniques for the econometric analysis of non-stationary time series to assess links and price convergence in petroleum product prices across Western African countries over time. One of the main ideas is to test whether petroleum product prices are co-integrated across the countries in the sub-region, controlling for movements in international prices. If this is the case, it will constitute evidence that there are pressures for arbitrage, with market forces imposing constraints on the administered retail prices set by national governments. In the case where no co-integration relationship is found, one can interpret that barriers to arbitrage, such as institutional constraints, physical distance and transport costs, dominate even in the longer term.

Furthermore, we also analyze cross-country linkages in oil prices and estimate a set of parsimonious vector-error-correction models that include the specific product retail prices in different countries as endogenous variables and a reference international price as an exogenous variable (also included in the co-integration vector). For this purpose, we use the Full Information Maximum Likelihood (FIML) procedure proposed by Pesaran and others (2000) to analyze long-run co-integration relationships in a multivariate framework.

This study focuses on three petroleum products prices in eight West African countries. It analyzes the prices of Gasoline, Diesel and Kerosene as they are considered the most, and in some countries, the only marketed products. We have studied the prices of these three products in six WAEMU member states, namely Benin, Burkina Faso, Côte d'Ivoire, Mali, Niger, and Togo, and two non-WAEMU states, Ghana and Nigeria. The choice of these eight countries is motivated by some characteristics relevant to our study. To name a few, most of these countries share porous borders, and some of these share also a common currency. In addition, Nigeria is an important oil producer and heavily subsidizes petroleum products. Ghana is expected to start oil production in 2011 and has also subsidized petroleum products over a large part of the sample period.

To ensure the accuracy and quality of the information used, all data come directly from country authorities in charge of setting the petroleum prices. In addition, all the prices used in the quantitative analysis are the prices at the pump and include all subsidies and taxes either for a specific endowment funds such as the Road Fund in Ghana, or for the state itself. Annex A provides a detailed description of variables included in the analysis.

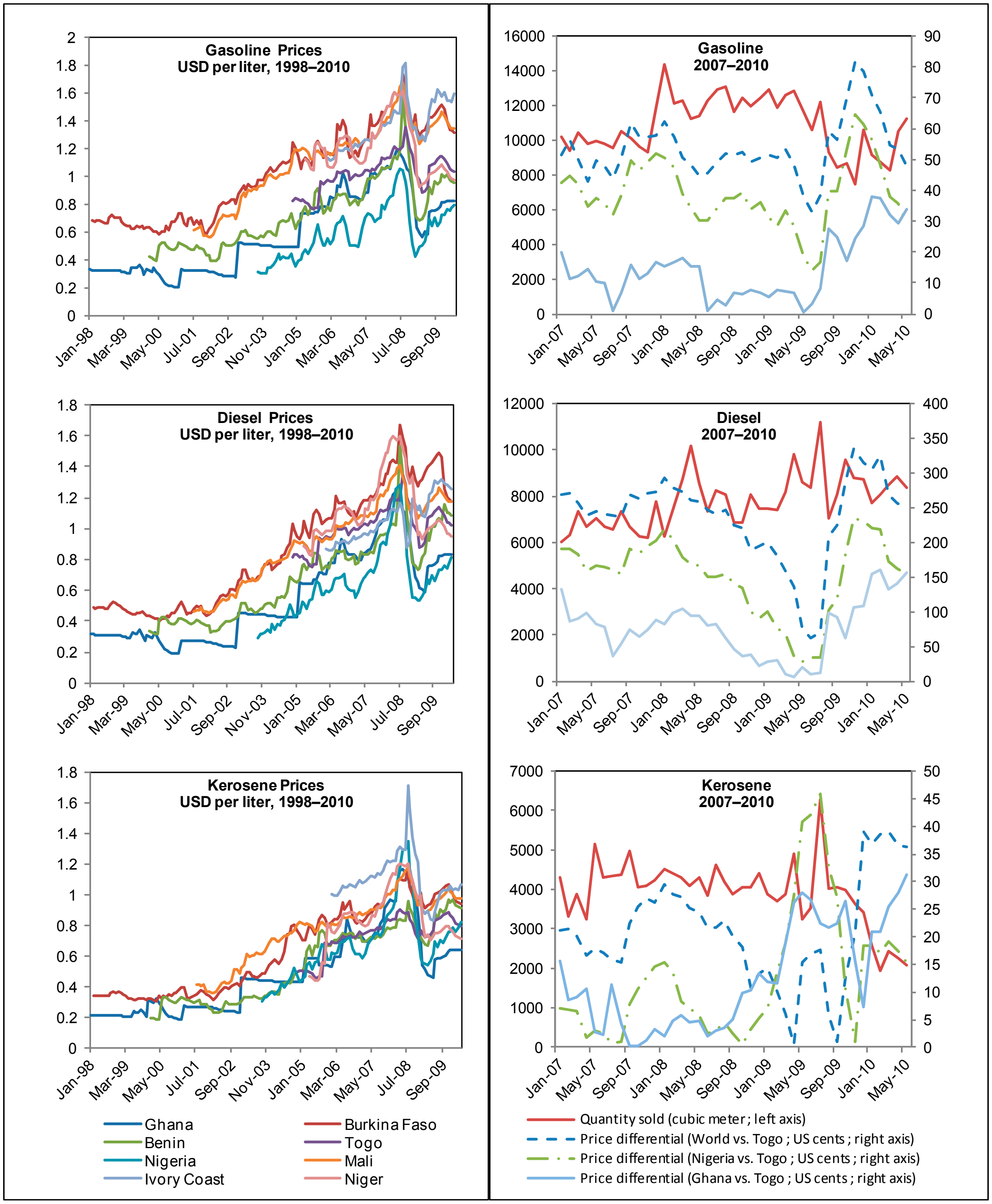
The three panels on the left-hand-side in Figure 2 illustrate the evolution over the period 1998 to 2010 of retail prices for the different types of petroleum products in the countries considered in this paper. The time series suggest significant co-movement in retail prices for the three types of products across the 8 countries, illustrating a strong association between changes in dollar-denominated prices. Differences in price levels (rather than price movements) could be attributed to several factors including transportation costs, differentials in tax rates, among others.

Furthermore, the three panels on the right-hand-side of the figure, present indicative evidence for Togo of the impact of price differentials across neighboring countries on the quantities of petroleum products sold domestically through the formal market over the period 2007-2010. The figure illustrate whether some of the provisioning for domestic demand for petroleum products is diverted to informal sources (through smuggling) during periods of high retail prices relative to neighboring countries. Togo was chosen as an example because of data availability, because it is not a country that produces petroleum products, and due to its relatively small size (both in spatial and economic terms), which arguably can facilitate the identification of the impact of international price differentials. For illustrative purposes, we chose to include in the Figure price differences between Nigeria and Togo, Ghana and Togo, and reference World Prices and Togo, such that an increase in the differential (an upward movement in the lines) indicate that domestic relative prices in Togo are high.

Domestic sales of gasoline and diesel appear to be negatively associated with price differentials between Nigeria relative to Togo and Ghana relative to Togo, particularly since early-2008, such that a decrease in differentials is linked to an increase in sales (and vice-versa). Especially, the increase in price differentials between May 2009 and early 2010 was clearly accompanied by a decline in domestic sales of gasoline and diesel in Togo. Domestic sales of kerosene also seem to be somewhat sensitive to movements in price differentials between Ghana and Togo in the later part of the time period considered, especially between the second and third quarters of 2009, when a reduction in the price differential in Togo relative to Ghana was associated with a spike in domestic sales and a subsequent increase in price differentials since late 2009 was accompanied by a decline in sales. Nevertheless, kerosene sales do not seem to respond to price differentials with respect to Nigeria. Overall, the data indicates some sensitivity of domestic sales of petroleum products to price differentials, but it is important to bear in mind that this constitutes only indicative evidence, as limitations in data availability prevent a formal econometric analysis of these impacts.

There are a number of preliminary issues that have to be addressed when modeling long-run relationships among variables using the approaches proposed in this paper. One fundamental problem is to ensure that all the variables that are included in the long-run co-integration relationship(s) are in fact non-stationary. Therefore, we present in Annex B alternative panel unit root tests for the retail prices of the different types of petroleum products. The test results strongly indicate that the variables under consideration are integrated of order 1 i.e. their levels contain unit roots, but the first differences are stationary. Furthermore, Tables in the Annex also confirm that these results hold at the individual country level.

Figure 2: Co-movement of Petroleum Product Prices and Indicative Impact of Price Differentials



Source: W3 Petroleum prices database, IMF country desks and PPPRA-Nigeria website.

We assess the role of market forces in determining retail prices for the three types of petroleum products considered by firstly testing whether there is convergence to some form of purchasing power parity for these products in the countries in the region. Adjustment to the “law of one price” would indicate that arbitrage forces in the goods market are at play leading to “home” and “foreign” prices for the specific products to converge. Smuggling could be a major factor in goods market arbitrage given the relatively porous borders that tend to characterize the region coupled with weak enforcement capacity by severely fiscally constrained governments. Another important channel could be arbitrage undertaken by petroleum product distributors themselves who could build-up stocks of petroleum products in a given country when relative prices are low and deplete stocks when prices are favorable relative to neighboring countries. This type of arbitrage could be particularly easy to implement in countries such as Togo and Benin that serve as important transit routes for these products to their landlocked northern neighbors (Burkina Faso, Mali and Niger).

Anecdotal evidence and perceptions by local policy makers suggest that illegal or informal (non-taxed and non-registered) trading in petroleum products in Western Africa is pervasive. For example, informal trading is estimated to account for over 50 percent of sales of petroleum products in Benin. This type of trade is a reflection of the strong incentives that observed price differentials provide to agents to search opportunities for arbitrage. Porous borders, weak enforcement capacity and corruption/bribery are also factors that foster informal or illegal trade.

To implement these tests we focus on bilateral prices between the eight countries considered for the different products. We define the log relative price of good k between country i and country j in period t as (where $e_{ij,t}$ refers to the log nominal exchange rate between country i and j):

$$q_{ij,t}^{k} = e_{ij,t} + (p_{i,t}^{k} - p_{j,t}^{k}) \qquad \textbf{(1)}$$

To test for convergence, we use panel techniques to assess whether the relative prices defined above are nonstationary. A rejection of the nonstationarity hypothesis would constitute evidence in favor of price convergence for good k between country i and j. We focus on four standard types of unit root tests. The Im, Pesaran and Shin (2003) and the Fisher-type ADF and PP test statistics assume heterogeneity among panel units. On the other hand, the Levin, Lin and Chu (2002) test statistic assumes that the panels share a common unit root process.

Tables 3 to 5 show summary results for the unit root tests for the different types of petroleum products. These are “aggregate” tests results at the panel level. The results for individual bilateral series are also presented in Annex C and are broadly in line with the panel level tests, as described further below. The tests that assume panel heterogeneity strongly reject the hypothesis for a unit root in gasoline prices at conventional significance levels, whereas the Levin, Lin and Chu (LLC) test only rejects the null of the seven percent level.

Similar results are obtained for the tests for kerosene prices. The Im, Pesaran and Shin (IPS) test rejects the null at the one percent level, whereas the LLC test only rejects the non-stationarity hypothesis at the eight percent level. The contrast in the conclusions of the different tests is starker for diesel prices. The tests that assume panel heterogeneity strongly reject the null of a unit root, whereas the LLC test does not reject it at conventional levels. In addition, Annex C presents IPS test results for each pair of bilateral relative prices, in other words for each country pair considered by itself without taking into account the panel dimension of the data, for the different types of petroleum products. When examining the bilateral prices, it is quite frequent that the null of non-stationarity cannot be rejected at conventional levels for the three types of products, which reflects the loss of power of the unit root tests when the panel dimension of the data is not utilized.

Table 3. Panel Unit Root Tests for Bilateral Gasoline Prices

Method	*Statistic*	*Probability*	*Cross-sections*	*Observations*
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.48	0.07	28	1913
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-st	-3.41	0.00	28	1913
ADF - Fisher Chi-square	100.53	0.00	28	1913
PP - Fisher Chi-square	91.41	0.00	28	1921

Countries covered are Benin, Burkina Faso, Ghana, Ivoiry Coast, Mali, Niger, Nigeria and Togo; Sample: 1998M01 to 2010M05.
Lag length selection based on SIC; NW bandwidth selection and Bartlett kernel.
Probabilities for Fisher tests computed using asymptotic Chi-square distribution.
All other tests assume asymptotic normality.

Table 4. Panel Unit Root Tests for Bilateral Kerosene Prices

Method	*Statistic*	*Probability*	*Cross-sections*	*Observations*
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.37	0.08	28	1908
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-st	-2.61	0.00	28	1908
ADF - Fisher Chi-square	76.91	0.03	28	1908
PP - Fisher Chi-square	76.43	0.04	28	1921

Countries covered are Benin, Burkina Faso, Ghana, Ivoiry Coast, Mali, Niger, Nigeria and Togo; Sample: 1998M01 to 2010M05.
Lag length selection based on SIC; NW bandwidth selection and Bartlett kernel.
Probabilities for Fisher tests computed using asymptotic Chi-square distribution.
All other tests assume asymptotic normality.

Overall, the test results indicate that there is strong evidence against the nonstationarity hypothesis of these bilateral prices. In fact, only the LLC test for Diesel retail prices indicates the presence of a unit root, but the conclusions of this test need to be taken with caution as they depend on the assumption that the series considered have a common unit root process, which is not likely to hold in our case given the diversity of the economies considered.

Table 5. Panel Unit Root Tests for Bilateral Diesel Prices

Method	*Statistic*	*Probability*	*Cross-sections*	*Observations*
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.58	0.28	28	1910
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-st:	-2.78	0.00	28	1910
ADF - Fisher Chi-square	85.25	0.01	28	1910
PP - Fisher Chi-square	86.52	0.01	28	1921

Countries covered are Benin, Burkina Faso, Ghana, Ivoiry Coast, Mali, Niger, Nigeria and Togo; Sample: 1998M01 to 2010M05.
Lag length selection based on SIC; NW bandwidth selection and Bartlett kernel.
Probabilities for Fisher tests computed using asymptotic Chi-square distribution.
All other tests assume asymptotic normality.

These results suggest a form of "weak" purchasing power parity for petroleum products in the region. In other words, barriers to arbitrage such as transport costs do not allow this petroleum products "real exchange rate" to be zero as predicted by strict purchasing power parity, nevertheless the "real exchange rate" eventually converges. The identification of the precise forces that would drive this convergence in prices is beyond the scope of this paper, but one possible channel could be smuggling and informal trade. For example, one country may have higher tax rates on petroleum products than a neighbor and this would provide strong incentives for smuggling from to "low tax" country to the "high tax" country, if the tax differential is large enough to cover transport and other costs. As long as the different tax regimes persist, the "high tax" would lose some tax revenue due to smuggling. Policy makers in the "high tax" country may decide to lower the tax rate to boost tax receipts by taxing a larger base. Regionally, such dynamics could yield some sort of race to the bottom in terms of taxing petroleum products (similar to what is document in the FDI literature)[8].

These econometric results support concerns of policy makers in smaller, non-oil producing countries about constraints to domestic pricing and the implementation of full pass-through of international prices posed by pricing policies and subsidies of neighboring countries. There is in fact a strong link between retail prices in the eight countries considered in the analysis, indicating that market forces do not allow prices to diverge for long periods of time (beyond more "fixed" characteristics that determine the level differential such as geography and transport costs). Therefore one clear policy implication of these results concerns the need

[8] A different issue arises when the administered price is set at a rate that does not cover import costs plus taxes. Profits from importing are eliminated, and shortages are likely to emerge. The losses generated in this way are usually absorbed by the government's budget.

to better coordinate adjustments of administered prices across countries in the region to avoid negative spillovers.

In the remainder of this section, we quantify the cross-country linkages identified above by estimating long-run models that include the US dollar denominated prices for the specific petroleum product (gasoline, kerosene or diesel) in Benin, Burkina Faso, Ghana, Côte d'Ivoire, Mali, Nigeria, Niger, and Togo as endogenous variables. In addition, international prices for each product are also included as non-stationary ("long-run forcing") exogenous variables in the models. For this purpose we use the long-run structural modeling approach proposed by Pesaran and others (2000) and estimate vector error correction models (VECMs) that include a vector z of random variables, partitioned between endogenous and exogenous variables of the following form:

$$\Delta z_t = a_0 + a_1 t + \sum_{l=1}^{n-1} \Gamma_l \Delta z_{t-l} + \Pi z_{t-1} + \zeta_t \qquad \textbf{(2)}$$

Where the first two terms on the right-hand-side of the expression represent deterministic components, Γ_l are short-run response matrices, Π is the long-run multiplier matrix and ζ_t is an error term. Note that the exogenous variables also enter each co-integration vector estimated. Therefore, a typical co-integration vector for the dollar prices would have the following form, where i, j and k are superscripts that indicate a country, w indicates World prices and the subscript g denotes a specific product (say gasoline):

$$p_g^i = \alpha p_g^j + \phi p_g^k + \beta p_g^w \qquad \textbf{(3)}$$

All variables included in the models are integrated of order 1 (see Annex B for tables presenting the different test statistics and the discussion earlier in this section). As we include exogenous I(1) variables in the models (namely the levels of international prices for the three products), the usual critical values for co-integration tests have to be modified and the appropriate values were tabulated by Pesaran and others, (ibid). An additional practical problem posed in the analysis relates to overparametrisation. It is a well known problem in the econometric literature that the number of coefficients to be estimated in a VECM model increases proportionately to the number of variables included in the system, thus increasing the amount of estimation error entering forecasts obtained from the model. Therefore, given the limitations in data availability, we decided to restrict the analysis to groupings of two or three countries at a time. These groupings were based on geographical proximity and anecdotal evidence of smuggling and spill-over effects.

Tables 6 to 8 present the estimation results obtained for these models. In the case of gasoline prices (Table 6), among the six models estimated only in one of them the relevant tests statistics (Trace and Maximum Eigenvalue) do not indicate the presence of at least one co-integration relationship at conventional levels of statistical significance, namely the model that includes retail prices in the Côte d'Ivoire and Mali. Therefore, the evidence of long-run links between gasoline retail prices among the different country groupings in the region is broadly confirmed.

Columns 5 to 8 in the table present estimates for the long-run multipliers of the impact of a change in the price in one country on the price in the other countries included in the model. For the model that includes Ghana and Togo (first row of the table), the estimated long multiplier of a change in retail gasoline prices in Ghana on prices in Togo is 0.57 and this estimate is statistically significantly different from zero at the 5 percent level. The estimates of long-run multipliers of a change in retail gasoline prices in Nigeria on prices in Benin is 0.68 and on prices in Niger is 4.51 (see second row of the table). Therefore, the spill-overs of changes in retail prices in Nigeria on prices in Niger tend to be much higher than spill-overs of prices in Nigeria on administered prices in Benin.

Intuitively, prices in smaller, non-oil producing countries tend to respond to price changes in larger and/or oil producing ones, perhaps because a smaller country is more vulnerable to smuggled fuel imports, and the government will find it difficult to sustain a higher tax rate and thus higher prices than in its neighbors without the tax base drying up. In fact, the multiplier estimates are in general statistically significant at conventional levels and range from 11 for the response of gasoline prices in Burkina to changes in prices in Ghana to -6.66 for the response of prices in Niger to prices in Benin. In fact, the latter negative estimate suggests that the administrative prices in both countries move in opposite directions which constitute evidence of a lack of coordination in price setting policies across these countries. The table also suggests that there is significant diversity in the size of the multipliers across the different country groupings considered, reflecting a high degree of heterogeneity of prices responses.

Furthermore, columns 9 to 11 present estimates of the coefficient for the error correction term in the respective error correction equation for each country (the elements of the Γ_l matrix in equation 2 above). This provides a measure of how fast retail prices converge to their long-run relationship in other words a “speed of adjustment” coefficient. The half-life of a unit shock (the amount of time it takes for 50 percent of the effect of the shock to die out) can be inferred from coefficient of ECM term in error correction equation using the following formula: ln(0.5)/ln(1+error correction coefficient).

The estimates obtained are quite diverse with some coefficients suggesting very quick adjustment to equilibrium for some countries and others suggesting a slow adjustment. For instance, the estimated half-life for prices in Benin in the model that includes Benin, Niger and Nigeria is just one month, but in the case of the model that includes Togo and Ghana, the half-life for prices in Togo is about 5 months. The estimated half-life for prices in Burkina Faso for the model that includes Burkina, Ghana and Côte d’Ivoire is about 35 months, indicating a very slow adjustment to equilibrium.

Table 6. Vector Error Correction Models for Gasoline Prices

Countries (i,j,k)	Obs.	Maximum Eigenvalue test	Trace Test	r>1	Long-run Elasticity ij	Long-run Elasticity ik	Long-run Elasticity ji	Long-run Elasticity jk	Error Correction Term (i)	Error Correction Term (j)	Error Correction Term (k)
	1	2	3	4	5	6	7	8	9	10	11
Ghana, Togo	144	20.81**	25.96**	No	1.77***	n.a.	0.57**	n.a.	-0.06**	-0.14***	n.a.
Benin, Niger, Nigeria	58	43.94**	60.47**	No	-0.15	0.68**	-6.66***	4.51**	-0.82***	-0.06***	-0.04***
Togo, Burkina	142	17.02*	19.75	No	0.43**	n.a.	2.33***	n.a.	-0.16***	0.07	n.a.
Burkina, Ghana, CIV	48	38.27**	49.08**	No	11.02***	5.80***	0.09	-0.53***	0.02**	-0.39***	0.03***
Mali, CIV	50	5.02	8.52	No	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Burkina, Benin, Togo	119	40.11**	50.92**	No	3.03***	0.45	0.33***	-0.15	0.01	-0.64***	-0.05

Each row reports results obtained for a VECM model that includes country i,j and k as specified. Note that international prices were included in all estimated VECMs. Column 1 reports the number of observations included in the VECM model. Columns 2 to 4 report results from co-integration tests. The Ho for both the maximum eigenvalue and the trace tests is that no co-integration relationship exists and the alternative hypothesis is the presence of at least one co-integrating vector. Column 4 indicates whether additional tests suggest more than one co-integrating vector. *,**,*** denote statistical significance at the 10%, 5% and 1% level respectively. In columns 5 to 8 LR test for over identifying restrictions was used. Columns 9 to 11 show the error correction coefficient for the error correction equation for country i,j and k respectively. n.a. indicates that the figure is not applicable.

Table 7 present the results of the models that include retail prices of kerosene for the different western African countries. It is interesting to note that the co-integration tests cannot reject the hypothesis of no co-integration relationship among these variables for several of the country groupings. This might be linked to the fact that these prices tend to be heavily subsidized due to the greater use of this product by poorer households and governments are more reluctant to adjust them (see previous sections).

In fact, only the models including the prices in Burkina Faso, Ghana, the Côte d'Ivoire and Mali seem to present statistically significant co-integration relationships. In addition, even for these countries prices seem to move in opposite directions over the long-run as the multipliers are negative[9]. This suggests that pricing policies are independent for this product among these countries and that policy makers do not take into consideration the possible spill-over effects on neighboring countries when setting domestic retail prices for kerosene. Nevertheless, the statistical results should be interpreted with caution given the small sample sizes for these two models (only 48 and 50 observations are available respectively).

In addition, the estimated error correction coefficients tend to suggest a slow adjustment to equilibrium, especially when compared to the results previously obtained for gasoline prices. The estimated half-life for kerosene prices in Burkina Faso is over 10 months. The half-life for kerosene prices in Mali is 17 months. Nevertheless, the coefficient estimates for the Côte d'Ivoire in the model that also includes Mali seem to be an exception with an estimated half-life of about one month[10]. Hence, the econometric results not only indicate a weaker link between kerosene prices across countries, but also adjustment to equilibrium when such relationships exists is typically much slower than it is the case for gasoline prices.

[9] Except for the response of prices in Burkina Faso to prices in Ghana and the response of prices in the Côte d'Ivoire to Prices in Mali, which are not statistically significant.

[10] Note that since the response of prices in the Côte d'Ivoire to prices in Mali is not statistically significant, the half-life actually reflects an adjustment towards the long-run link between Ivoirian prices and international ones (which are always included in the models).

Table 7. Vector Error Correction Models for Kerosene Prices

Countries (i,j,k)	Obs.	Maximum Eigenvalue test	Trace Test	r>1	Long-run Elasticity ij	Long-run Elasticity ik	Long-run Elasticity ji	Long-run Elasticity jk	Error Correction Term (i)	Error Correction Term (j)	Error Correction Term (k)
	1	2	3	4	5	6	7	8	9	10	11
Ghana, Togo	145	12.53	12.69	No	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Benin, Niger, Nigeria	58	10.37	18.52	No	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Togo, Burkina	143	13.54	13.99	No	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Burkina, Ghana, CIV	48	34.44**	51.56**	No	-0.06	-2.30***	-17.07***	-39.20***	-0.07***	-0.002**	-0.003***
Mali, CIV	51	34.00**	37.23**	No	-3.55***	n.a.	-0.28	n.a.	-0.04***	-0.70***	n.a.
Burkina, Benin, Togo	119	14.07	25.43	No	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Each row reports results obtained for a VECM model that includes country i,j and k as specified. Note that international prices were included in all estimated VECMs. Column 1 reports the number of observations included in the VECM model. Columns 2 to 4 report results from co-integration tests. The Ho for both the maximum eigenvalue and the trace tests is that no co-integration relationship exists and the alternative hypothesis is the presence of at least one co-integrating vector. Column 4 indicates whether additional tests suggest more than one co-integrating vector. *,**,*** denote statistical significance at the 10%, 5% and 1% level respectively. In columns 5 to 8 LR test for over identifying restrictions was used. Columns 9 to 11 show the error correction coefficient for the error correction equation for country i,j and k respectively. n.a. indicates that the figure is not applicable.

The estimates for models including the retail price of diesel in the different countries are presented on Table 8. The results are somewhat aligned with the results obtained for gasoline prices. In most models, the hypothesis of no co-integration relationship between the variables is rejected at conventional levels. Nonetheless, the hypothesis of no co-integration is not rejected for the model that includes Mali and the Côte d'Ivoire and it is only rejected at the 10 percent level for the maximum eigenvalue test statistic for the model that considers the links between prices in Togo and Burkina Faso. Most of the estimated long-run multipliers are statistically significant at conventional levels. They vary between 2.8 for the change in prices in Benin and Niger following a change in prices in Nigeria (see the second row of the table) to -1, the long-run multipliers for changes in prices in Benin following price changes in Niger and vice-versa.

As was the case for gasoline prices, the error correction estimates suggest a diverse pattern of adjustment. The estimated half-life coefficients range from one month to over 10 months, which overall suggest a typically faster speed of adjustment when compared to the results obtained for kerosene and gasoline prices. For example, the half-life of diesel prices in Togo is about seven months when considering the adjustment to their long-run relationship to prices in Ghana according to the models estimated. The estimated half-life for prices in Burkina Faso in the model that also includes Ghana and the Côte d'Ivoire is about three months and the half-life of prices in Benin in the model that includes Niger and Nigeria is less than two months.

Overall, our results indicate that there is strong evidence of convergence in petroleum product prices across the countries included in the analysis. In addition, the estimation results from the VECMs suggest the presence of long-run links between gasoline retail prices among the different country groupings in the region with long-run multipliers of the impact of a change in the price in one country on the price in the other countries ranging from 11 for the response of gasoline prices in Burkina to changes in prices in Ghana to -6.66 for the response of prices in Niger to prices in Benin. The speed of adjustment to long-run equilibrium varies significantly according to the country groupings considered. The results for diesel prices are somewhat aligned with the results obtained for gasoline prices. The estimated long-run multipliers vary between 2.8 to -1 and the error correction estimates suggest a diverse pattern of adjustment. In contrast, the econometric results for kerosene prices not only indicate a weaker link between prices across countries, but also a much slower adjustment to equilibrium compared gasoline prices when such relationships exist.

Table 8. Vector Error Correction Models for Diesel Prices

Countries (i,j,k)	Obs.	Maximum Eigenvalue test	Trace Test	r>1	Long-run Elasticity ij	Long-run Elasticity ik	Long-run Elasticity ji	Long-run Elasticity jk	Error Correction Term (i)	Error Correction Term (j)	Error Correction Term (k)
	1	2	3	4	5	6	7	8	9	10	11
Ghana, Togo	144	20.05**	24.67**	No	0.68**	n.a.	1.47***	n.a.	-0.07*	-0.10***	n.a.
Benin, Niger, Nigeria	57	36.32**	49.92**	No	-0.99***	2.76***	-1.01***	2.80***	-0.56***	-0.26***	-0.05
Togo, Burkina	141	11.16	13.62	No	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Burkina, Ghana, CIV	48	30.97**	36.27*	No	-1.04***	0.60***	-0.96***	0.58***	-0.29***	-0.29***	0.11
Mali, CIV	51	10.31	13.41	No	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Burkina, Benin, Togo	118	27.87**	38.67*	No	1.77***	0.27	0.56***	-0.15	0.13**	-0.61***	0.04

Each row reports results obtained for a VECM model that includes country i,j and k as specified. Note that international prices were included in all estimated VECMs. Column 1 reports the number of observations included in the VECM model. Columns 2 to 4 report results from co-integration tests. The Ho for both the maximum eigenvalue and the trace tests is that no co-integration relationship exists and the alternative hypothesis is the presence of at least one co-integrating vector. Column 4 indicates whether additional tests suggest more than one co-integrating vector. *,**,*** denote statistical significance at the 10%, 5% and 1% level respectively. In columns 5 to 8 LR test for over identifying restrictions was used. Columns 9 to 11 show the error correction coefficient for the error correction equation for country i,j and k respectively. n.a. indicates that the figure is not applicable.

IV. Conclusions and Policy Implications

Policy makers in smaller Western African countries frequently point to externalities and subsidies in neighboring countries as an important constraint to the adoption of first best policies in terms of setting retail prices for petroleum products. Even if national policy makers believe that adjustments in the prices of petroleum products should in principle reflect medium and long-term market trends, it is frequently argued that smuggling and other arbitrage channels impose limits on the extent of pass-through of international prices to domestic retail prices. Regional characteristics such as porous borders compound this problem. In addition, smuggling and informal trade can have important consequences in terms of loss of government tax or customs revenue from these products.

The results of the econometric analysis presented in previous sections confirm that cross-country spillovers stemming from differences in pricing policies are economically important, even if the size of these spillovers varies considerably across countries and petroleum products. Hence, this paper provides some empirical basis for the arguments put forward by Western African policy makers. Intuitively, prices in smaller, non-oil producing countries tend to respond to price changes in larger and/or oil producing ones (such as Ghana and Nigeria), perhaps because a smaller country is more vulnerable to smuggled fuel imports, and the government will find it difficult to sustain a higher tax rate and thus higher prices than in its neighbors without the tax base drying up.

Therefore, the pervasive use of ad-hoc administered pricing policies for petroleum products in the region introduces distortions and, in the absence of a liberalized market, the potential benefit of fostering some form of coordination in terms of principles regarding pricing adjustments and tax policy at the regional level becomes apparent in light of the important spillovers identified in this paper. From an institutional perspective, a regional body such as the ECOWAS commission could play a role in promoting a dialogue on setting agreed general principles for price setting mechanisms and on encouraging coordination and convergence in adjustment policies across national governments. One benefit of dialogue would be that countries that are "market leaders" (especially larger/oil producing countries) would internalize some of the spillovers of their own policies on their neighbors. Nevertheless, while some policy dialogue and convergence would be desirable, it is clear that differences in price levels across countries will persist to some degree, reflecting in large part differences in geography (landlocked vs. coastal countries) and resource endowments (oil producers vs. oil importers).

Even if regional coordination along these lines is not feasible in the short to medium term, the countries in the region should set policy objectives that take fully into account the trade-offs inherent to administered prices, in particular the need to balance the desire for volatility smoothing with the fiscal implications and risks linked to the non-adjustment of prices. A complete analysis of the fiscal costs and fiscal risks associated with administered prices in the region is beyond the scope of this paper, but would constitute a priority area for future research and regional policy dialogue. It is also possible that the ECOWAS commission could play a role in boosting efforts to coordinate tax policy towards petroleum products to ensure that current differentials in retail price levels are not conducive to smuggling or other forms of arbitrage.

General principles to be followed by pricing mechanisms include the need to make price adjustments automatic (rather than discretionary) and frequent in order to mitigate fiscal risks. In this context, the governance structure of the institutions in charge of implementing the price formula is also an important element of the pricing policy. The pricing formula should be insulated from political influence, perhaps by delegating its implementation to an independent body, transparently organized, that includes representatives from the different stakeholders (importers, distributors, transporters, etc.) and with appropriate disclosure to the public.

In several cases, the binding constraints lie in the implementation of policies with countries having *de jure* automatic adjustment mechanisms that are suspended in difficult times. The reluctance of governments to fully pass through increases in international prices can frequently be attributed to political economy considerations. In fact, more affluent sectors of the population and the urban middle class, which tend to be politically vocal groups, benefit more directly from the implicit or explicit subsidies to retail prices of petroleum products. Another prominent source of concern is the impact of increases in fuel prices on the real incomes of the poor. Nevertheless, the available evidence suggests that subsidies to petroleum product prices tend to be regressive.

Although full liberalization might be the first best option, given a country's history and institutional context it might be reasonable from an economic point of view to continue with a policy of administered prices in the medium-run, with the application of frequent and automatic adjustments. A fully liberalized regime would require adequate regulation to ensure the prevalence of competitive practices, which might be difficult in the case of low income countries, where regulatory capacity is weak and the size of the market tends to be small (thus reducing the number of market players). A simple, transparent and automatic pricing mechanism would ease the administrative burden of price regulations.

Furthermore, it is also reasonable to explore targeted compensatory measures to mitigate the impact of eventual price fluctuations on the poor. Generally, research suggests that well targeted subsidies and compensatory measures are more effective at alleviating poverty than subsidies to petroleum products, which also tend to have high opportunity costs (see Baig and others, 2007, and Coady and others, 2010). In Ghana, for instance, increases in oil prices in 2006 were accompanied by measures such as additional funding for primary health care programs (see, Baig and others, 2007). The effect of oil price increases on the poor could be also be mitigated by more indirect policies such as additional investments in infrastructure and public transportation.

The preferred policy responses to both spillovers and pricing mechanisms are fully compatible. The establishment in countries across the region of predictable, transparent and politically sustainable pricing mechanisms for petroleum products reflecting world prices would not only be good national policy but would also mitigate the risk and costs of spillovers.

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A. Annex: Variables Definitions and Sources

Variables	Definitions/Notes	Sources
Retail prices for gasoline	Log of monthly prices at the pump for the different countries.	W3 Petroleum prices database, IMF country desks and PPPRA-Nigeria website.
Retail prices for kerosene	Log of monthly prices at the pump for the different countries.	W3 Petroleum prices database, IMF country desks and PPPRA-Nigeria website.
Retail prices for diesel	Log of monthly prices at the pump for the different countries.	W3 Petroleum prices database, IMF country desks and PPPRA-Nigeria website.
International prices for gasoline	Log of monthly Rotterdam (ARA) Conventional Gasoline prices.	U.S. Energy Information Administration.
International prices for kerosene	Log of monthly Rotterdam (ARA) Kerosene prices.	U.S. Energy Information Administration.
International prices for diesel	Log of monthly U.S. Gulf Coast No 2 Diesel prices.	U.S. Energy Information Administration.
Bilateral Nominal Exchange Rates		IMF/IFS Database.
Quantities of petroleum products sold domestically	Quantities sold within Togo in cubic meters for the three types of petroleum products.	Data provided by country authorities, PPPRA-Nigeria website and National Authority Petroleum of Ghana website.

B. Annex: Panel Unit Root Tests for Gasoline, Kerosene and Diesel Prices

Panel Unit Root Test Result for Gasoline [1 2]

Method	*Statistic*	*Probability [3]*	*Cross-sections*	*Observations*
Level				
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.43681	0.3311	8	849
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-st	0.16875	0.567	8	849
ADF - Fisher Chi-square	11.5783	0.7725	8	849
PP - Fisher Chi-square	10.6249	0.832	8	852
First Difference				
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-25.3038	0	8	844
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-st	-22.0474	0	8	844
ADF - Fisher Chi-square	384.143	0	8	844
PP - Fisher Chi-square	384.294	0	8	844

[1] Countries covered are Benin, Burkina Faso, Ghana, Ivoiry Coast, Mali, Niger, Nigeria and Togo; Sample: 1998M01 2010M05.

[2] Automatic lag length selection based on SIC: 0 to 3; Newey-West automatic bandwidth selection and Bartlett kernel.

[3] Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel Unit Root Test Result for Kerosene [1 2]

Method	*Statistic*	*Probability [3]*	*Cross-sections*	*Observations*
Level				
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.25004	0.4013	8	845
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-st:	0.20457	0.581	8	845
ADF - Fisher Chi-square	15.7995	0.467	8	845
PP - Fisher Chi-square	10.9652	0.8116	8	852
First Difference				
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-26.3162	0	8	842
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-st:	-22.3214	0	8	842
ADF - Fisher Chi-square	388.409	0	8	842
PP - Fisher Chi-square	400.163	0	8	844

[1] Countries covered are Benin, Burkina Faso, Ghana, Ivoiry Coast, Mali, Niger, Nigeria and Togo; Sample: 1998M01 2010M05.

[2] Automatic lag length selection based on SIC: 0 to 3; Newey-West automatic bandwidth selection and Bartlett kernel.

[3] Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel Unit Root Test Result for Diesel [1 2]

Method	*Statistic*	*Probability* [3]	*Cross-sections*	*Observations*
Level				
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.71798	0.2364	8	847
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-st	0.6323	0.7364	8	847
ADF - Fisher Chi-square	10.4152	0.8441	8	847
PP - Fisher Chi-square	7.96949	0.9498	8	852
First Difference				
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-24.2067	0	8	843
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-st	-21.5493	0	8	843
ADF - Fisher Chi-square	373.435	0	8	843
PP - Fisher Chi-square	396.109	0	8	844

[1] Countries covered are Benin, Burkina Faso, Ghana, Ivoiry Coast, Mali, Niger, Nigeria and Togo; Sample: 1998M01 2010M05.

[2] Automatic lag length selection based on SIC: 0 to 3; Newey-West automatic bandwidth selection and Bartlett kernel.

[3] Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Im, Pesaran and Shin W-stat Test Result for Gasoline and Kerosene [1 2]

Gasoline

Method	*Statistic*	*Probability [3]*
Im, Pesaran and Shin W-stat	0.16875	0.567

Intermediate ADF test results

Series	*t-Stat*	*Prob.*	*E(t)*	*E(Var)*	*Lag*	*Max Lag*	*Observations*
BENIN	-1.5701	0.4948	-1.532	0.735	0	12	121
BURKINA	-0.8104	0.8128	-1.532	0.735	0	13	143
GHANA	-0.9827	0.7586	-1.532	0.735	0	13	147
IVOIRY COAST	-1.538	0.5065	-1.526	0.759	0	10	51
MALI	-1.6542	0.4515	-1.53	0.745	1	12	104
NIGER	-1.6989	0.4266	-1.52	0.771	1	10	59
NIGERIA	-2.3788	0.151	-1.524	0.751	1	11	78
TOGO	-1.1826	0.6812	-1.532	0.735	0	13	146
Average	-1.477		-1.528	0.746			

Kerosene

Method	*Statistic*	*Probability [3]*
Im, Pesaran and Shin W-stat	0.20457	0.581

Intermediate ADF test results

Series	*t-Stat*	*Prob.*	*E(t)*	*E(Var)*	*Lag*	*Max Lag*	*Observations*
BENIN	-0.6204	0.8608	-1.532	0.735	0	12	121
BURKINA	-0.3913	0.9064	-1.532	0.735	0	13	143
GHANA	-1.4807	0.5407	-1.53	0.745	1	13	146
IVOIRY COAST	-1.8863	0.336	-1.526	0.759	0	10	51
MALI	-1.4881	0.5358	-1.53	0.745	1	12	104
NIGER	-2.6962	0.0809	-1.487	0.807	3	10	57
NIGERIA	-2.7805	0.0658	-1.502	0.763	2	11	77
TOGO	-0.3252	0.9171	-1.532	0.735	0	13	146
Average	-1.4586		-1.521	0.753			

[1] Countries covered are Benin, Burkina Faso, Ghana, Ivoiry Coast, Mali, Niger, Nigeria and Togo; Sample: 1998M01 2010M05.

[2] Automatic lag length selection based on SIC: 0 to 1; Null Hypothesis: Unit root (individual unit root process)

[3] Probabilities are computed assuming asympotic normality.

Im, Pesaran and Shin W-stat Test Result for Diesel [1 2]

Method	*Statistic*	*Probability [3]*
Im, Pesaran and Shin W-stat	0.6323	0.7364

Intermediate ADF test results

Series	*t-Stat*	*Prob.*	*E(t)*	*E(Var)*	*Lag*	*Max Lag*	*Observations*
BENIN	-1.0342	0.7394	-1.532	0.735	0	12	121
BURKINA	-0.6425	0.8562	-1.532	0.735	0	13	143
GHANA	-1.0074	0.7498	-1.53	0.745	1	13	146
IVOIRY COAST	-1.365	0.5921	-1.526	0.759	0	10	51
MALI	-1.4278	0.5659	-1.53	0.745	1	12	104
NIGER	-1.6257	0.4633	-1.52	0.771	1	10	59
NIGERIA	-2.6044	0.0965	-1.502	0.763	2	11	77
TOGO	-0.9491	0.77	-1.532	0.735	0	13	146
Average	-1.332		-1.525	0.749			

[1] Countries covered are Benin, Burkina Faso, Ghana, Ivoiry Coast, Mali, Niger, Nigeria and Togo; Sample: 1998M01 2010M05.

[2] Automatic lag length selection based on SIC: 0 to 1; Null Hypothesis: Unit root (individual unit root process)

[3] Probabilities are computed assuming asympotic normality.

C. Annex: Panel Unit Root Tests for International Relative Prices

Im, Pesaran and Shin W-stat Test Result for Bilateral Relative Gasoline Prices [1 2]

Method	*Statistic*	*Probability* [3]
Im, Pesaran and Shin W-stat	-3.41262	0.0003

Intermediate ADF test results

Series	*t-Stat*	*Prob.*	*E(t)*	*E(Var)*	*Lag*	*Max Lag*	*Observations*
BENIN vs. BURKINA	-3.5955	0.0072	-1.532	0.735	0	12	120
BENIN vs. GHANA	-2.2339	0.1976	-1.525	0.765	0	9	45
BENIN vs. IVOIRY COAST	-1.7889	0.3816	-1.527	0.761	0	10	49
BENIN vs. MALI	-3.3685	0.0144	-1.532	0.735	0	12	103
BENIN vs. NIGERIA	-2.3362	0.1635	-1.524	0.751	1	11	76
BENIN vs. NIGER	-2.0366	0.2708	-1.521	0.751	0	10	58
BURKINA vs. GHANA	-1.1823	0.6738	-1.525	0.766	0	9	44
BURKINA vs. IVOIRY COAST	-2.2494	0.1923	-1.526	0.762	0	10	48
BURKINA vs. NIGERIA	-2.0099	0.2821	-1.523	0.752	1	11	75
BURKINA vs. NIGER	-1.3106	0.6188	-1.521	0.752	0	10	57
IVOIRY COAST vs. GHANA	-1.1545	0.6862	-1.526	0.763	0	9	47
IVOIRY COAST vs. NIGERIA	-2.7622	0.0711	-1.524	0.781	1	10	50
IVOIRY COAST vs. NIGER	0.0041	0.9545	-1.525	0.758	0	10	52
MALI vs. BURKINA	-3.3596	0.0147	-1.532	0.735	0	12	102
MALI vs. GHANA	-1.4229	0.5632	-1.526	0.763	0	9	47
MALI vs. IVOIRY COAST	-1.6871	0.4316	-1.526	0.759	0	10	51
MALI vs. NIGERIA	-2.2684	0.1847	-1.524	0.751	1	11	78
MALI vs. NIGER	-1.0718	0.7213	-1.52	0.771	1	10	59
NIGERIA vs. GHANA	-2.522	0.117	-1.522	0.79	1	9	46
NIGERIA vs. NIGER	-1.7432	0.4047	-1.52	0.771	1	10	59
NIGER vs. GHANA	-2.3633	0.1574	-1.526	0.763	0	9	47
TOGO vs. BENIN	-3.8613	0.0031	-1.532	0.735	0	12	121
TOGO vs. BURKINA	-3.2447	0.0195	-1.532	0.735	0	13	143
TOGO vs. GHANA	-1.4911	0.5292	-1.525	0.764	0	9	46
TOGO vs. IVOIRY COAST	-0.363	0.9073	-1.527	0.76	0	10	50
TOGO vs. MALI	-2.313	0.1699	-1.532	0.735	0	12	104
TOGO vs. NIGERIA	-1.957	0.305	-1.524	0.751	1	11	77
TOGO vs. NIGER	-2.725	0.0759	-1.52	0.75	0	10	59
Average	-2.0864		-1.526	0.756			

[1] Countries covered are Benin, Burkina Faso, Ghana, Ivoiry Coast, Mali, Niger, Nigeria and Togo; Sample: 1998M01 2010M05.

[2] Automatic lag length selection based on SIC: 0 to 1; Null Hypothesis: Unit root (individual unit root process)

[3] Probabilities are computed assuming asympotic normality.

Im, Pesaran and Shin W-stat Test Result for Bilateral Relative Kerosene Prices [1 2]

Method	*Statistic*	*Probability* [3]
Im, Pesaran and Shin W-stat	-2.60731	0.0046

Intermediate ADF test results

Series	*t-Stat*	*Prob.*	*E(t)*	*E(Var)*	*Lag*	*Max Lag*	*Observations*
BENIN vs. BURKINA	-3.3502	0.0148	-1.532	0.735	0	12	120
BENIN vs. GHANA	-0.9444	0.7645	-1.522	0.794	1	9	44
BENIN vs. IVOIRY COAST	-1.0145	0.7411	-1.527	0.761	0	10	49
BENIN vs. MALI	-1.1256	0.7035	-1.532	0.735	0	12	103
BENIN vs. NIGERIA	-2.5009	0.1193	-1.524	0.751	1	11	76
BENIN vs. NIGER	-1.8046	0.3748	-1.521	0.751	0	10	58
BURKINA vs. GHANA	-1.4688	0.5396	-1.521	0.796	1	9	43
BURKINA vs. IVOIRY COAST	-1.6242	0.4627	-1.526	0.762	0	10	48
BURKINA vs. NIGERIA	-1.8031	0.3764	-1.523	0.752	1	11	75
BURKINA vs. NIGER	-2.1679	0.22	-1.521	0.752	0	10	57
IVOIRY COAST vs. GHANA	-2.0275	0.2745	-1.526	0.763	0	9	47
IVOIRY COAST vs. NIGERIA	-1.9621	0.3022	-1.524	0.781	1	10	50
IVOIRY COAST vs. NIGER	-2.119	0.2383	-1.525	0.758	0	10	52
MALI vs. BURKINA	-1.9807	0.2949	-1.532	0.735	0	12	102
MALI vs. GHANA	-1.4446	0.5523	-1.522	0.79	1	9	46
MALI vs. IVOIRY COAST	-2.0648	0.2594	-1.526	0.759	0	10	51
MALI vs. NIGERIA	-1.9318	0.3163	-1.524	0.751	1	11	78
MALI vs. NIGER	-2.2754	0.1832	-1.52	0.771	1	10	59
NIGERIA vs. GHANA	-2.3098	0.1733	-1.522	0.79	1	9	46
NIGERIA vs. NIGER	-1.6993	0.4264	-1.52	0.771	1	10	59
NIGER vs. GHANA	-2.1792	0.2163	-1.526	0.763	0	9	47
TOGO vs. BENIN	-3.1284	0.0271	-1.532	0.735	0	12	121
TOGO vs. BURKINA	-2.9458	0.0427	-1.532	0.735	0	13	143
TOGO vs. GHANA	-1.5355	0.5067	-1.522	0.792	1	9	45
TOGO vs. IVOIRY COAST	-1.7651	0.3931	-1.527	0.76	0	10	50
TOGO vs. MALI	-1.7305	0.413	-1.532	0.735	0	12	104
TOGO vs. NIGERIA	-2.7571	0.0693	-1.524	0.751	1	11	77
TOGO vs. NIGER	-1.0775	0.719	-1.52	0.772	1	10	58
Average	-1.9549		-1.525	0.761			

[1] Countries covered are Benin, Burkina Faso, Ghana, Ivoiry Coast, Mali, Niger, Nigeria and Togo; Sample: 1998M01 2010M05.

[2] Automatic lag length selection based on SIC: 0 to 1; Null Hypothesis: Unit root (individual unit root process)

[3] Probabilities are computed assuming asympotic normality.

Im, Pesaran and Shin W-stat Test Result for Bilateral Relative Diesel Prices [1 2]

Method	*Statistic*	*Probability* [3]
Im, Pesaran and Shin W-stat	-2.78132	0.0027

Intermediate ADF test results

Series	*t-Stat*	*Prob.*	*E(t)*	*E(Var)*	*Lag*	*Max Lag*	*Observations*
BENIN vs. BURKINA	-3.0957	0.0295	-1.532	0.735	0	12	120
BENIN vs. GHANA	-1.3461	0.5999	-1.525	0.765	0	9	45
BENIN vs. IVOIRY COAST	-2.2822	0.1816	-1.527	0.761	0	10	49
BENIN vs. MALI	-2.8361	0.0568	-1.532	0.735	0	12	103
BENIN vs. NIGERIA	-2.5251	0.1136	-1.524	0.751	1	11	76
BENIN vs. NIGER	-1.3018	0.6231	-1.521	0.751	0	10	58
BURKINA vs. GHANA	-1.254	0.6424	-1.525	0.766	0	9	44
BURKINA vs. IVOIRY COAST	-2.0022	0.285	-1.523	0.788	1	10	47
BURKINA vs. NIGERIA	-1.6402	0.4572	-1.523	0.752	1	11	75
BURKINA vs. NIGER	-1.2515	0.6459	-1.521	0.752	0	10	57
IVOIRY COAST vs. GHANA	-1.7164	0.4165	-1.522	0.79	1	9	46
IVOIRY COAST vs. NIGERIA	-2.3686	0.1556	-1.524	0.781	1	10	50
IVOIRY COAST vs. NIGER	-1.1406	0.6927	-1.524	0.78	1	10	51
MALI vs. BURKINA	-2.6471	0.087	-1.532	0.735	0	12	102
MALI vs. GHANA	-1.3781	0.585	-1.526	0.763	0	9	47
MALI vs. IVOIRY COAST	-1.9369	0.3132	-1.524	0.781	1	10	50
MALI vs. NIGERIA	-1.9235	0.32	-1.524	0.751	1	11	78
MALI vs. NIGER	-0.7281	0.8312	-1.52	0.771	1	10	59
NIGERIA vs. GHANA	-1.7226	0.4134	-1.522	0.79	1	9	46
NIGERIA vs. NIGER	-1.5582	0.4974	-1.52	0.771	1	10	59
NIGER vs. GHANA	-2.2303	0.1987	-1.526	0.763	0	9	47
TOGO vs. BENIN	-3.743	0.0046	-1.532	0.735	0	12	121
TOGO vs. BURKINA	-3.4055	0.0123	-1.532	0.735	0	13	143
TOGO vs. GHANA	-1.4476	0.5508	-1.525	0.764	0	9	46
TOGO vs. IVOIRY COAST	-0.833	0.8008	-1.527	0.76	0	10	50
TOGO vs. MALI	-2.4394	0.1336	-1.532	0.735	0	12	104
TOGO vs. NIGERIA	-1.8483	0.3549	-1.526	0.736	0	11	78
TOGO vs. NIGER	-2.9273	0.0482	-1.52	0.75	0	10	59
Average	-1.9832		-1.525	0.759			

[1] Countries covered are Benin, Burkina Faso, Ghana, Ivoiry Coast, Mali, Niger, Nigeria and Togo; Sample: 1998M01 2010M05.

[2] Automatic lag length selection based on SIC: 0 to 1; Null Hypothesis: Unit root (individual unit root process)

[3] Probabilities are computed assuming asympotic normality.