Renewable Portfolio Standards

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More than half of U.S. states require that a minimum share of the electricity sold to their residents come from renewable sources. These rules, called renewable portfolio standards (RPSs), share the common goal of substituting electricity generated by renewable sources for that generated by fossil fuels, thereby reducing local air pollution and greenhouse gases.

Are they effective? The Natural Resources Defense Council has claimed that RPSs have been a big driver of renewables growth. And the Lawrence Berkeley National Lab writes that "roughly half of all growth in U.S. renewable electricity generation and capacity since 2000 is associated with state RPS requirements." But recent academic studies by economists find little or no evidence that RPSs have been a significant cause of U.S. renewables growth.

Asking whether RPSs have worked as intended is more complicated than it may seem, for multiple reasons. First, in all but two states, utilities can comply either by reducing the amount of electricity they purchase generated from fossil fuels, which is the goal, or by increasing the amount generated by renewable sources, which has no environmental benefit. Second, utilities in states with RPSs typically purchase some power generated in other states. Third, some of the renewable sources of electricity in the U.S. would likely have been built even in the absence of RPS rules, thanks to other environmental rules or because generating electricity from wind and solar power has become cost-effective at market prices. And fourth, for complicated reasons stemming from the way researchers typically assess the stringency of RPS rules—in megawatt hours of renewables required—that stringency may itself be endogenous.

We combine the best aspects of prior economic analysis, attempting to address each of these four complications. Our results corroborate their findings, that RPS policies to date have done little to increase renewables or decrease fossil fuel use. In one specification, we find that RPSs are responsible for, at most, 11 percent of the electricity generated from wind sources in the U.S. since 2000, and none of the electricity from solar. However, we are cautious about the results, given their variability across different specifications and implausibility in the case of some outcomes.

It is possible, of course, that RPSs to date have been ineffective because in most states they have been insufficiently strict. That may be changing, as many states with RPSs have announced plans to tighten them in the near future. It is also possible that a federal, nationwide renewable policy would be more effective, given that 20 U.S. states currently do not have an RPS.

What is clear, no matter the specification chosen or explanation for the outcome, is that claims that RPSs have been responsible for a significant portion of US renewables growth to date cannot be supported by current evidence.

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The Threshold Role of FDI Flows in the Energy-Growth Nexus: An Endogenous Growth Perspective

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FDI flows to sub-Saharan African countries have risen and plunged in recent years, fluctuating precariously. At the same time, a burgeoning literature is hyping on the role of FDI flows in the relationship between energy consumption and economic growth. One aspect of this relationship is the precariousness of FDI flows and their implications for the nexus between energy consumption and economic growth. Technically, studies have emphasized the role of intervening variables between economic growth and energy consumption and authors have used a good number of variables to account for what is highlighted in the causality literature as omitted variable. Empirically, the role of FDI flows in this study is additionally helpful in interpreting the data and the relationship more logically. Therefore, for sub-Saharan African countries that have experienced a bout of spurts and trickles of FDI flows, the implications for the four energy-growth hypotheses – namely, (i) the growth hypothesis, (ii) the conservation hypothesis, (iii) the feedback hypothesis and (iv) the neutrality hypothesis – are worth investigating. In particular, the study seeks to answer to the question of which of these hypotheses holds if the FDI flows rise or fall.

Many aspects of the data on sub-Saharan African countries call for close scrutiny. The phenomenon of cross-sectional dependence, for example, occupies a frontal methodological space in our analysis. For obvious reasons, accounting for and treating cross-sectional dependence is clearly necessary. For example, the questions of policy affinity, geographical proximity and simultaneous response to global shocks as well as the recent trade integration of African countries through the AFCFTA suggest the need to account for cross-sectional dependence. A number of cross-sectional dependency tests show that the data could not reject the cross-sectional dependence. At the same time, we entertain the stationarity testing. It is particularly important to do this because the adopted methods – the lag-augmented VAR and its variant adopted for sensitivity test the lag-variable-augmented VAR – require the inclusion of the highest stationarity order of integration. As part of the methodological novelty of the study, we introduce the bootstrap method to overcome the problem associated with the finite sample. Given its superiority over the finite sample approach to testing, our results are interpreted based on the bootstrap p-values.

Estimating the basic and extended models, we report the following findings. For the basic model, both asymptotic and bootstrap p-values suggest that there is a neutrality between energy use and economic growth, thus highlighting a policy-mix without a recourse to a trade-off between income expansion and energy use. Based on the bootstrap p-values, the obtained results suggest that the extended model accounting for cross-sectional dependence does not change the neutrality between energy use and economic growth, although the asymptotic p-value indicates there is a feedback effect from economic growth to energy use at 10% level. The neutrality suggests that energy and economic policies are not conflicting in those sub-Saharan countries.

The introduction of FDI flows as a threshold variable into the basic and the cross-sectionally corrected model indicates the neutrality hypothesis cannot be rejected using the bootstrap

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p-value whereas the asymptotic p-value indicates that both energy use and economic growth are mutually feeding back into the system. This obviously conflicting evidence results from the finite sample bias for which the bootstrap is robust. Thus, based on the bootstrap p-value, the data support the evidence of neutrality whether FDI flows are contracting or expanding. This implies that spurts and bursts in FDI flows do not particularly interfere with neutrality either in the small or large data-set. However, when FDI flows directly drive energy use which in turn drives economic growth, it is found that economic growth impacts energy use in the expanding phase of FDI flows only, thus subscribing to the energy conservation hypothesis.

Overall, our results imply that using energy more efficiently and substituting one type of energy for another, such as substituting natural gas for oil or oil for biomass in light of oil discoveries in some countries, could be a good policy option. Nevertheless, individual countries need to consider the growth in FDI flows. The implication of this result suggests that an energy demand policy, such as an energy conservation policy, would not cause any significant adverse side-effects on economic growth in those sub–Saharan African countries.

Green Bonds for Renewable Energy in Latin America and the Caribbean

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This paper comprehensively analyzes the overall status of the green bond market in Latin America and the Caribbean (LAC) for the renewable energy (RE) sector. In this way, regardless of all the advances in the study of green bonds, we identify a gap in the analysis of the dimension and determinants of green bonds in the renewable energy sector in the LAC region, which plays a pivotal role in the RE scene worldwide.

The RE green bond market in LAC emerged in 2014, and although slower than the broader green bond market, it has grown an average of 52% annually, with 2019 being the most active year by volume and number of deals. In fact, 38.34% of the universe of green bonds in LAC corresponds to bonds with RE-oriented funds, which makes it the primary sector by use of funds. However, in this period, only ten countries —or 30% of the countries in LAC— have issued RE green bonds. Furthermore, the market is relatively concentrated, with three countries accounting for 73% of the resources raised, namely, Brazil (47%), Mexico (14%), and Peru (10%). These results can be partly explained by new regulatory frameworks designed to facilitate the financing of sustainable investments by increasing the participation of the private sector in these countries.

Our results highlight the small presence of local governments in the RE green bond market. This suggests that regulators should be encouraged to relax barriers to local governments, as they restrict an important green bond niche. Remarkably, the resources allocated to RE by financial issuers are very small, with only 1% of the volume and 4% of the transactions. Consequently, government support for RE green bonds is crucial, as there is extraordinary potential for sovereign issuances not yet present in RE.

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Despite LAC's low perception of transparency, 78% of the volume issued for RE projects and 58% of the operations have been externally reviewed. In any case, these values are slightly lower than those of the broad green bond market due to the high incidence of private placements. Remarkably, we have not found a sufficient number of post-issuance reports to allow us to provide information on this aspect in the region. In this context, it is essential to improve the presence and dissemination of such information to help dispel doubts about the final destination of the funds.

Although the presence and promotion of development finance institutions for issuing green bonds in the RE sector have greatly improved in recent years, it is necessary to continue progressing on this point. Furthermore, investors should promote a more significant commitment to training programs by companies that are already issuers, counteracting the lack of knowledge and the perceived risks regarding the costs, administrative procedures, and reputational risks that these operations entail. For that purpose, closer cooperation and alliances are essential to share responsibilities and knowledge in LAC.

Climate Policy and Strategic Operations in a Hydro-Thermal Power System

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In conjunction with the European Union (EU) target to reduce greenhouse gas emissions by 55% by 2030 relative to 1990 levels, the Nordic countries aim to decarbonise their power sectors by 2040. While phasing out of fossil-fuelled power plants and integration of variable renewable energy (VRE) technologies, such as wind and solar power, could pose a challenge, the Nordic region appears relatively well positioned to cope with this sustainable energy transition. Indeed, with its vast hydro reservoirs and ample transmission capacity, the regional electricity market, Nord Pool, is held up as an exemplar with low carbon intensity and limited scope for the exercise of market power. Thus, intermittencies stemming from the widespread adoption of VRE could be mitigated by deploying flexible assets such as hydro storage.

Although market-clearing prices in Nord Pool are generally close to marginal costs, empirical evidence hints at the potential exercise of market power from hydro reservoirs, strategic withholding from fossil-fuelled plants, and collusion among jointly owned nuclear plants. Moreover, game-theoretic analyses of the Nordic region identify situations in which owners of flexible plants could exploit their leverage to exert market power. Such strategic behaviour by hydro reservoirs could be exacerbated in a future power system with a high CO_2 price and greater VRE penetration due to the additional need for flexibility. In such a situation, strategic hydro reservoirs would have a stronger incentive to conduct temporal arbitrage, viz., by withholding their production during peak periods and increasing it during off-peak ones. In effect, they would have the potential to increase (decrease) market-clearing prices during peak (off-peak) periods even if they did not "spill" their annual production.

The prospect for this type of distortion to arise in the future Nordic power system has not yet been addressed. In particular, the empirical studies have used data from 2011-2013, whereas the

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game-theoretic models have treated hydro as a generic flexible resource without explicit modelling of reservoir constraints. Given the ramifications for other hydro-thermal power systems and generic storage devices from the exertion of temporal arbitrage, we devise a Nash- Cournot framework with a representation of the Nordic region's spatio-temporal features and reservoir operations in order to address the following research questions (RQs):

1. How are social welfare, reservoir operations, and CO_2 emissions affected by market power in the current Nordic power system?
2. What will be the impact of future climate policy comprising a high CO2 price and expanded VRE capacity on the potential for the exercise of market power by both hydro and thermal producers?

In terms of RQ 1, we implement numerical cases for the year 2018 in which either all firms are perfectly competitive (PC), large firms behave à la Cournot in thermal generation (COG), or large hydro reservoir owners behave à la Cournot (COR). Using the average EU Emissions Trading System (ETS) price of €15/t for 2018, we find that modelled electricity prices under PC are close to the observed ones for the year. Market power in thermal generation as in COG leads to withholding of nuclear capacity, which causes prices and CO_2 emissions to soar as relatively costly and polluting gas-fired plants operate more. Such exertion of market power is not plausible because it would be obvious to market inspectors. However, temporal arbitrage as in COR that deploys more water from reservoirs in the off-peak season (spring) and less in peak seasons (winter and fall) results in subtly higher electricity prices and an increase of 1.99% in producer surplus for the largest hydro-owning firm vis-à-vis PC. This is in spite of a regulatory constraint that forces such firms to generate the same annual energy from reservoirs as under PC.

We address RQ 2 by devising a plausible year-2030 scenario with a CO_2 price of €100/t and double the year-2018 VRE capacity in the firms' existing portfolios. The purpose of this so-called 2030CV scenario is to explore how structural changes to the supply side stemming from climate policy affect the leverage exerted by strategic hydro- reservoir and thermal producers. Consequently, gas-fired plants become uneconomical, CO_2 emissions decrease by over 90% relative to 2018 levels, and equilibrium prices are about 25% lower than those in 2018. More important, there is increased benefit to firms from exerting market power via either thermal or hydro-reservoir generation. Relative to 2018, nuclear plants are more likely to be price setters, which makes it easier for them to raise the price under COG by withholding output to render gas-fired plants as the marginal technology. As for COR, reservoir operators face less of a barrier in shifting water from peak to off-peak seasons for three reasons. First, the lower prices in the peak seasons mean less forgone revenue from shifting production away. Second, increased intermittency from VRE output enables "excess" hydro generation to be exported. Third, decreased gas-fired generation due to the high CO_2 price means less of a response by price-taking flexible producers to such temporal arbitrage. These factors culminate in an 11.9% increase in the largest hydro-owning firm's producer surplus vis-à-vis PC. Hence, future climate policy could enhance the prospects for the exercise of market power even in the Nordic region.

A Quantitative Model of the Oil Tanker Market in the Arabian Gulf

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The market for oil tankers is an important component of the supply chain for crude oil, yet this market has remained poorly understood, owing to the paucity of time series data and the absence of an empirical framework for studying its determinants. Our work advances this literature in several ways. First, we construct a new data set of key economic indicators for the market for very large crude carriers (VLCCs) from the Arabian Gulf to East Asia for January 1991 through October 2019.

Second, we develop a structural vector autoregressive framework for this market that allows us to quantify the determinants of these indicators. This is a major advance in that existing studies of oil tanker markets to date have focused on documenting lead-lag relationships and reduced-form correlations without addressing the underlying identification problem.

Third, using state-of-the-art econometric methods, we quantify the causal effects of tanker cost, utilization, tanker supply and tanker demand shocks on the volume of oil exports from the Arabian Gulf, bunker fuel prices, one-year VLCC time charter rates, round-trip VLCC voyage rates from the Arabian Gulf to East Asia, and the profits of owners of VLCCs chartered for round-trip voyages on this route. Our estimates are informative, economically intuitive, and relevant for understanding today's oil tanker market.

We show that a positive tanker cost shock has a negligible effect on the real time charter rate, but higher voyage costs are associated with a decline in the demand for time charters because charterers' profits are reduced by higher operating costs. This helps explain the decline in the overall volume of oil exports from the Arabian Gulf. The magnitude of this response is small, consistent with the view that the demand for shipping is fairly inelastic with respect to changes in freight costs. Moreover, real voyage profits decline in response to positive cost shocks, suggesting that cost shocks are only partially passed on to round-trip voyage rates. This finding is consistent with the fact that real roundtrip rates increase in response to positive cost shocks only with a delay. Positive utilization shocks are associated with higher profits, an increase in time charter rates and lower fuel prices and oil export volumes. Tanker supply and tanker demand shocks have persistent effects on time charter rates as well as on the volume of oil exports and the bunker fuel price with the expected sign. Lower tanker supply and higher tanker demand are reflected in persistently higher voyage profits for vessel owners as well as higher round-trip voyage rates.

Whereas the variability of the real voyage profits of ship owners and round-trip voyage rates depends mainly on utilization shocks and tanker demand shocks, that of time-charter rates depends first and foremost on tanker demand and supply shocks. The variability of bunker fuel prices mainly depends on tanker demand and supply shocks, followed by tanker cost shocks, with utilization shocks playing only a small role. The main determinants of the variability of the volume of oil exports are tanker demand, tanker cost shocks and utilization shocks.

Our analysis also allows us to quantify the extent to which the historical evolution of oil exports, bunker fuel prices, time charter rates, round-trip voyage rates and shipowner profits is explained by each of the structural shocks. The results are reasonably robust across model spec-

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ifications. We find that, until 2008, the volume of oil exports from the Arabian Gulf was largely determined by tanker demand shocks, consistent with conventional wisdom. Since then cost shocks have been the main determinant. Interestingly, there is robust evidence of a tanker-demand driven spike in oil export volumes (as well as in both tanker rates) associated with the temporary détente in U.S. trade policy in 2018/19, confirming that trade disputes have real effects on industrial commodity markets.

Cost shocks have only minor effects on the evolution of real time charter rates. The demand-driven cycle in time charter rates largely mirrors that found in oil export volumes and voyage profits. Between 2010 and 2015 (and again between 2016 and 2019), there is evidence of a trough in real time charter rates caused by the cumulative effects of tanker supply shocks, consistent with the delivery of many newly built vessels during this period. Finally, the results for the real round-trip voyage rate from the Arabian Gulf to East Asia and for the real vessel owners' profits from these round-trip voyages are qualitatively similar. The historical evolution of these variables is more sensitive to utilization and tanker demand shocks than tanker supply or cost shocks.

Coal-Biomass Co-firing within Renewable Portfolio Standards: Strategic Adoption by Heterogeneous Firms and Emissions Implications

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With the liberalization of electricity markets and increasing concerns about greenhouse gas emissions, several voluntary regulatory schemes have been proposed to reduce CO_2 emissions in the electric power sector. One of these schemes is allowing coal-biomass co-firing as a carve-out within a Renewable Portfolio Standard (RPS). Coal-biomass co-firing is proposed as a means to reduce carbon emissions and at the same time extend the economic life of coal generators that have struggled to compete with natural gas and renewable sources.

The emissions reduction that would result from a voluntary technology standard depends critically on which subset of the existing producers choose to adopt the new technology. Previous studies of the impacts from encouraging coal-biomass co-firing have used simple heuristic assumptions such as all coal plants co-fire or only the most polluting units receive the retrofit. Moreover, previous analyses of this question have applied cost-minimization methods from a fictional central planner perspective.

The economic theory of electricity markets and more than 20 years of observed market behavior have demonstrated that, when possible within market rules, producers sometimes exercise market power to influence electricity prices and increase their profit. Electricity producers can attempt to exercise market power either through strategic bidding into day-ahead and real-time markets or through their long-term investment decisions.

In this study, we investigate the emissions reductions that would result from coal-biomass co-firing when each coal-fired generator retrofits only when it would increase its own profit. We

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apply a game-theoretic framework that represents strategic adoption by each producer and includes chronological hourly temporal resolution and intertemporal constraints on the production technology.

We present a case study based on the Midwestern U.S. electricity market and demonstrate that a coal-biomass co-firing carve-out target that requires a subset of coal-fired plants to retrofit would likely increase the carbon emissions from the system. This result is a consequence of the relative economic incentives for retrofitting, which is most favorable for coal plants with a mid-range marginal cost. We show that the plants with the lowest marginal costs are already competitive and would receive a lower profit with biomass co-firing; similarly, the highest marginal cost generators are unlikely to increase their output after adopting co-firing and would also have lower profits with the new technology. The implication for voluntary technology standards is that the promised environmental benefits may not be realized and depends critically on the relative incentives for adoption across firms with heterogenous costs.

Intraday Return Predictability in the Crude Oil Market: The Role of EIA Inventory Announcements

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The US Energy Information Administration (EIA) releases the Weekly Petroleum Status Report and provides estimates of the inventory levels of crude oil and petroleum products every Wednesday at 10:30 Eastern Time (ET). The inventory announcements significantly impact the crude oil market and, subsequently, the real economy.

We analyze the impact of EIA inventory announcements on the crude oil market from the perspective of intraday return predictability. We complement previous studies about intraday momentum, which generally focus on the predictability of the first half-hour on the last half-hour returns of the same day. More specifically, we examine whether and to what extent the EIA inventory announcements affect the pattern of intraday return predictability.

We report three key findings: (i) the third half-hour returns (when news is released) on EIA announcement days can significantly and positively predict the returns in the last half-hour, whereas, on non-EIA announcement days, only returns in the first half-hour have significant predictability; (ii) on days with EIA announcements, investors pay more attention to the forthcoming inventory news releases than to the information released overnight; (iii) the importance of the third half-hour returns for the EIA group is more apparent during periods of high volatility and periods when active portfolio management is required.

Our contributions are three-fold. First, we document the importance of EIA announcements for an intraday momentum strategy, an issue that has received little attention to date. Second, we show that the predicting source of the first half-hour returns on non-EIA days comes from the overnight component, the return between the price at market open and the previous day's price at market close. This finding adds to the understanding of the role of overnight returns in intraday momentum. Third, we explore the theoretical mechanisms in the different predictive sources in

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third half-hour returns by connecting them to informed trading and liquidity provision. Overall, our analysis contributes to understanding the theoretical framework explaining different patterns in intraday momentum and provides practical implications for the market participants.

The influence of OPEC+ on oil prices: A quantitative assessment

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The advent of US shale oil has substantially changed the structure of global oil production. The emergence of the US as a dominant market player has had profound implications for the strategic behaviour of other oil producers; in particular for those coalesced in the Organization of Petroleum Exporting Countries (OPEC). Whereas OPEC, which includes large producers like Saudi Arabia, Iraq, Iran and the United Arab Emirates, has gradually lost market shares for the past ten years, US producers have been able to double their oil market shares over the period. The US is by now not only the largest oil producer in the world, it has also become an oil exporter, after a ban that prevented US firms to sell oil abroad was lifted in December 2015. In an attempt to regain some control over crude prices, OPEC and a number of other non-US oil producers forged an alliance in 2016, known as OPEC+. Among non-OPEC members, this coalition includes large producers like Russia, Mexico and Kazakhstan. The strategy adopted by OPEC+ consists of setting explicit production targets for each member with the aim of bringing oil inventories down to their 2010-2014 average.

In March 2020, the OPEC+ agreement was shaken by the Covid-19 shock. As mobility collapsed due to containment measures adopted on a global scale, demand for oil and the price of crude tumbled. When OPEC, in particular its unofficial leader Saudi Arabia, suggested the implementation of further production cuts to lift the price of crude, Russia refused to cooperate, arguing that US producers would gain the most from new efforts to prop up prices. The standoff between Saudi Arabia and Russia lasted more than a month and contributed to exacerbating a supply glut of historical proportions. Eventually a new agreement was reached and a new round of production cuts agreed upon, but this episode showed vividly how the oil market balance is crucially intertwined with the effectiveness of the OPEC+ coalition in influencing prices.

Our paper assesses the impact of the OPEC+ coalition on the price of oil between January 2017 and January 2020, intentionally excluding the period affected by the Covid-19 shock. Understanding the impact of the OPEC+ agreement is not only relevant for the members of the alliance as even small changes in oil prices will have significant effects on revenues earned on oil exports. This matters also from a global perspective as supply-driven oil price changes affect global economic growth.

Using structural vector autoregressive (SVAR) models we construct counterfactual scenarios that allow us to quantify how oil production and the price of oil would have evolved, had the OPEC+ agreement not been in place. The empirical strategy consists of computing a counterfactual path of global oil production assuming that all the fall in the production of OPEC+ after December 2016 can be attributed to an exogenous shift in their oil supply. Our counterfactual path of oil production is then constructed assuming that OPEC+ would have kept production steady at the level recorded before OPEC+ started implementing production cuts in line with the agreed upon targets. To evaluate the effects of these production cuts on the price of crude, we use two complementary

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specifications in our SVAR models. The first is a small model in which we pool together OPEC+ production with that of other producers. In the second specification, we split the production of OPEC+ from that of the rest of the world, allowing for strategic interactions between these two large oil producing blocks.

We find that the impact of OPEC+ on the price of crude oil varied over time, together with the cohesion of the coalition, and that it was overall quantitatively modest. Averaging over the whole period under analysis, our results indicate that the price of oil would have been around 4 USD per barrel lower, had OPEC+ not cut production. It would have taken a much deeper cut in oil production and a much stronger cohesion to achieve the ambitious target that the coalition had set for itself. Nevertheless, the economic consequences of the OPEC+ agreement for its members were not negligible. Given their crude production, the gains in export revenues due to higher crude oil prices account for about 8-10 billion US dollar per year for the two largest OPEC+ members Saudi Arabia and Russia.

Residential CO_2 Emissions in Europe and Carbon Taxation: A Country-Level Assessment

Dorothée Charlier,[a] Mouez Fodha,[b] and Djamel Kirat[c]

CO_2 emissions from the residential sector represent an important concern for climate policy design. The residential sector accounts for around 20% of European CO_2 emissions, with energy demand mainly driven by heating. Because emissions from the residential sector are difficult to displace to other countries, implementing climate policies could be effective but a clear understanding of their consequences is required. Issues like energy taxation and prices as well as carbon mitigation and redistribution are often connected to this sector.

The first objective of this paper is to study the determinants of CO_2 emissions from the residential sector in 19 European countries over the 2000-2017 period. We first estimate a static model that assumes an instantaneous adjustment of CO_2 emissions per capita to variations in energy prices, income or heating needs. We then relax this assumption and extend the static model to account for dynamic adjustments. We distinguish short-term from long-term elasticities of per capita CO_2 emissions relative to each driver. Our results show strong relationships between CO_2 emissions per capita, GDP per capita, energy prices and heating needs. We found that the income elasticity of CO_2 emissions per capita is not constant and depends on the level of GDP per capita. When instantaneous adjustment is assumed, the elasticities of per capita CO_2 emissions relative to natural gas and heating-oil prices are found to be -0.23 and -0.14 respectively. The corresponding short-term elasticities from dynamic models are -0.12 and -0.11, and the long-term elasticities estimated to be -0.47 and -0.38. We also confirm that CO_2 emissions per capita increase with heating needs, the short-run elasticities fall between 0.77 and 0.85, and the corresponding long-run elasticities are three times higher.

The second objective of this paper is to examine whether a carbon tax can be an effective complement to the EU ETS for emissions that remain unregulated, like those from the residential sector. We measured the consequences of the tax on CO_2 emissions and how the burden of this tax is distributed among countries. Imposing a European carbon tax could increase the regressive prop-

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erties of carbon taxation, which could result in a popular rejection of the policy. Our econometric estimates were used to predict which countries would bear the largest increase in energy prices from a European carbon tax. We assumed a 100% pass-through rate of the tax into energy prices and assessed the short-term impacts of the tax policy. We confirmed that this tax leads to inequalities in the tax burden, as measured by the ratio of tax revenues to GDP by country. Our simulations show for example that a carbon tax of €20 per tonne represents 0.02% of the Danish GDP but 0.17% of that of Poland in terms of tax revenue. Finally, we propose a policy that may correct for these inequalities. It consists of the redistribution of carbon tax revenues in order to obtain, ex-post, an equal tax-to-GDP ratio among all countries. We show that the main beneficiaries would be Poland, the Czech Republic and Belgium, while Denmark, Spain and Luxembourg would have to pay a surtax.

Gender, Energy Expenditure and Household Cooking Fuel Choice in Nigeria

Jennifer Uju Dim[a]

Traditional fuel (e.g. firewood, charcoal, animal dung) use for household cooking is a main source of indoor air pollution, which is a leading cause of premature deaths in developing countries. Women and children are disproportionately affected by the adverse effects of traditional fuel usage since they mostly do the cooking in their families. Hence, understanding women's role in the household fuel decision making process is critical in determining what type of fuel is chosen by a given household. This paper contributes to the existing literature by investigating the likelihood of a specific household to adopt clean cooking fuels when women have intra-household bargaining power and can influence the household fuel decision-making process. It also attempts to understand the determinants of household energy spending which is crucial for designing effective modern energy transition policies. Using different proxies of women intra-household bargaining power such as household head, relative spouse education and relative spouse age, the findings suggest that families where women have strong within-household bargaining power are more likely to adopt clean fuels as their primary cooking fuel as opposed to traditional fuels. This implies that policies such as women empowerment programs that enhance women's participation in the household decision-making process would promote the adoption of modern cooking fuels. In addition, income, education and proximity to forests are found to be crucial factors that influence not only household cooking fuel choice but also fuel expenditure.

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What Should be Taken into Consideration when Forecasting Oil Implied Volatility Index?

Panagiotis Delis,[a] Stavros Degiannakis,[b] and Konstantinos Giannopoulos[c]

Oil price volatility has triggered the attention of investors, portfolio managers and policy makers last decades. Most of the studies that focus on oil volatility forecasting use realized volatility as a volatility measure. In this study, we aim to develop a forecasting methodology on the most informative volatility measure, namely the oil volatility index (OVX), which is also looking-forward by nature, for the crude oil market.

This is the first study that develops HAR modeling frameworks by investigating the added value of other markets' IV indices (e.g. foreign exchange and commodity markets) in forecasting OVX. Moreover, since the long memory feature is prerequisite for the use of the HAR model, the investigation of the long memory as well as the incorporation of the dynamic model averaging (DMA) estimation technique make the contribution of the paper significant for both academics and investors.

The results show that the inclusion of the VXD in the modeling framework is considered of major significance and enhances the predictive ability of the models implemented on short- and mid-run forecasting horizons. This is in line with the literature that finds a strong relationship of oil price volatility and stock markets. More specifically, from this finding, we draw the conclusion that the implied volatility reflecting the future uncertainty of the largest companies' stocks prices is highly significant for generating accurate OVX forecasts. For longer horizons, the Energy Sector ETF Volatility Index (VXXLE) appears to have predictive information on OVX, which is explained by the fact that both focus on energy related uncertainty. Furthermore, it is observed that the various DMA models belong to the set of the best models, especially for short- and mid-run forecasting horizons, contrary to the simple HAR models that belong to the set of the best models at mid- and long-run forecasting horizons.

From the results of the paper, we suggest that academics and forecasters should take into account the strong existence of long memory in the time series of IV indices, which also justifies the use of the HAR model. Moreover, relying on the findings of this study, the IV indices from other asset classes offer incrementally higher forecasting accuracy of crude oil volatility, which is a useful outcome for future research.

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Distributed Renewable Energy Investment:
The Effect of Time-of-Use Pricing

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A transition from flat rate (FR) to time-of-use (TOU) pricing is widely adopted by electric utilities, which may affect firm's distributed renewable energy (DRE) investment. TOU pricing scheme usually sets a higher electricity tariff in the peak period and a lower one in the off-peak period. Theoretically, in a TOU pricing scheme the setting of peak and off-peak time periods and the number of time periods will both affect the economics of renewable energy technology.

This paper contributes to investigate the effect of TOU pricing on firm's DRE investment, taking into account the intermittency of renewables as well as the firm's electricity demand. First, a cost minimization model is constructed to determine the optimal DRE investment level for a non-power generating firm. Second, we derive the conditions under which electricity pricing (either TOU or FR pricing) leads to a higher level of DRE investment. Meanwhile, the effects of TOU pricing (i.e., peak, off-peak prices and times, price signals) on firm's optimal DRE investment decision are assessed. Third, we generalize the model to handle the case of three-period TOU pricing.

The modeling results show that the TOU pricing in contrast with FR pricing can lead to a higher investment level when the DRE technology under TOU pricing is more desirable and the firm's average electricity consumption during peak period is high. Moreover, it is found that the firm's optimal investment strategy is not necessarily sensitive to the price signal of TOU pricing (i.e., the ratio of peak to off-peak price). Specifically, when the service-level difference in meeting firm's electricity consumption between peak and off-peak periods by adopting DRE technology is above a threshold, a strong price signal will not promote the firm's optimal DRE capacity investment. Conversely, the firm's optimal capacity investment will increase in the price signal. The above conditions are determined by electricity demand and availability during peak and off-peak periods, which are highly dependent on the details of peak and off-peak times. In addition, we find that implementing full retail prices compensation for firm's surplus renewable electricity is probably not good as it may lead to DRE over-investment.

Based on these findings, we suggest that firms should first pay attention to peak time when making DRE investment decisions under TOU pricing scheme. To encourage DRE investment, it is vital to ensure different prices occur at the right times, as this will stimulate the firms sourcing with DRE technology in reaction to the price signal. One interesting implication is that "getting the time right" may be more important than "getting the price right" in terms of encouraging DRE investment. For net metering compensation design, maintaining the ratio of buyback price to electricity retail price below the ratio of costs to benefits by investing DRE technolgy cannot only stimulate investing but also prevent over-investing.

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What Drives Corporate Funding Spreads of Oil Companies: Evidence from the Integrated, Upstream and Downstream Industries

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Highlights:

- We analyse the determinants of corporate funding spreads using credit default swaps of the world's largest oil companies in the integrated, upstream and downstream, industry over the 2007-2020 period covering the 2008 financial crisis, oil plunge crisis and Covid-19 pandemic

- Oil companies operating in the upstream industry have the largest magnitude to oil price shocks and their CDS spread compared with firms operating in the integrated and downstream industries.

- The largest magnitude to downstream companies CDS spreads was observed during the Covid-19 pandemic

- The integrated firms have a similar trend with the upstream firms concerning oil price shocks and CDS spreads, but the magnitude of responses is much smaller. However, we did not find any significant impacts on the CDS spreads of firms that operate in the downstream industry.

- The practical implications of this research can be highlighted as: i. provides opportunities to exploit arbitrage in the derivative markets on CDS referenced entities between upstream and downstream companies under oil price shocks and thereby increasing overall price efficiency, ii. provides debt investors and issuers with more precision in evaluating debt funding spreads between companies that operate in the upstream and downstream industries and therefore more accuracy around pricing, book building and launching of new debt instruments and ii. it points to oil price shocks as a major contributor exacerbating systematic risk for oil companies with exposure to debt capital in the upstream industry and thus impacting equity values.

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