Governance, Environmental Vulnerability, and PM2.5 Concentrations: International Evidence

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Air pollution is a fundamental cause of climate change. Air pollution is mainly attributable to human activities that have a negative impact on the environment. As global population grows and industrialization, urbanization and modernization spreads across the globe, air quality has steadily deteriorated, especially in the developing world. Air pollution and climate change are often considered two sides of the same coin, adversely affecting many aspects of human life, particularly human health. Air pollution is the leading cause of respiratory diseases and has a pronounced effect on children's respiratory function.

However, since air pollution is mostly caused by human activity, it is preventable. In this study, we highlight the importance of governance and environmental vulnerability in pursuing cleaner air. The ability of a government to tackle environmental degradation could be hindered by the quality of public services, civil service, policy formulation, policy implementation and credibility of the government's commitment to a cleaner environment. Such institutional factors are captured in the Government Effectiveness index by the World Governance Indicators, which is the main indicator used in this study. We explicitly incorporate two key underlying factors, namely governance and environmental vulnerability, into the empirical analysis of air pollution for a global sample of countries.

More specifically, we examine the relationship between fine particulate matter (PM2.5) concentrations, and governance, environmental vulnerability, and other factors for a panel data of 128 countries from 2000 to 2014. Apart from data availability for a relatively large number of countries, we chose PM2.5 as the proxy for air pollution since the PM2.5 problem has recently attracted a lot of scientific and public attention. This is attributable to its harmful effects on visibility, human health, and global climate.

PM2.5 is widely recognized as a "major global killer" by the World Health Organization (WHO). Since PM2.5 is fine enough to lodge deep into human lung and blood tissue, populations exposed to PM2.5 are at risk of heart and lung diseases, ranging from stroke to lung cancer, which might cause death in severe cases. Furthermore, fine particulates such as PM2.5 are a main contributor to the incidence of pneumonia, which is a major cause of child mortality worldwide. PM2.5 is primarily the consequence of combustion, whether manmade like car emissions and coal burning, or natural like forest fires and volcanic activity. Despite its well-known health impact, PM2.5 is not monitored properly in many countries, especially in the developing world, due to lack of capacity, resources, and public demand.

For the full sample of countries, we find that better governance in terms of higher government effectiveness and higher educational attainment contribute to cleaner air. On the other hand, greater vulnerability causes air quality degradation. In theory, the effect of governance and environmental vulnerability on the environment is uncertain. However, the findings of this study indicate that better governance and reduced vulnerability (or higher educational attainment) benefit air

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quality. This suggests that promoting governance quality and educational programmes as well as tackling issues related to environmental vulnerability can contribute to cleaner air.

Our evidence on the environmental effects of governance and environmental vulnerability for different income groups of countries is more nuanced. The positive effect of environmental vulnerability on the level of PM2.5 concentrations holds across countries of different income levels. At the same time, a significantly negative effect of governance is found for high-income countries, but not for low- and middle-income countries, at the 5% significance level. The evidence thus suggests that developed countries have been more successful in tackling air pollution than developing countries.

On the other hand, developing countries are still struggling to find ways to grow rapidly without harming air quality. We also find that the coefficients of interaction terms between governance and vulnerability are negative while those between governance and education are positive. This implies that enhancing governance quality may reduce the negative effects of vulnerability on environmental performance. The results are robust to two different measures of governance quality.

The empirical findings underlie the central role of a strong institutional framework that facilitates policy formulation and implementation in addressing environment challenges. In countries with improved governance, firms tend to pursue more innovative activities that reduce environmental vulnerability. For instance, billions of dollars' worth of new cleaner technologies has dramatically reduced industrial pollutants and discharges in the US, leading to a fall in PM2.5 concentration levels by 30 percent between 2000 and 2018, according to a recent report by the U.S. Environmental Protection Agency.

This study points to a number of areas to improve governance quality and tackle environmental vulnerability in the developing world. Possible areas include enhanced public environmental awareness and educational programmes. Finally, the efforts of developing countries to grow rapidly without harming the environment would benefit greatly from the support of the international community. The support will improve their environmental institutional capacity and augment their environment-protecting resources.

Oil Price Volatility is Effective in Predicting Food Price Volatility. Or is It?

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The spikes in the prices of internationally traded agricultural commodities and oil in 2008 and 2011 and the associated food inflation have raised concerns about the impact of food price volatility on both consumers and producers across the world.

Understanding food price volatility is important for three main reasons. First, it affects hedging costs of agricultural firms. Second, increased food price volatility affects food security and malnutrition, which is a key concern for policy makers. Third, commodity markets (including food

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and oil markets) have attracted the interest of financial investors, and as a consequence have become more financialised and thus, more volatile. The increased financialisation has also resulted in the strengthening links between oil and agricultural commodities, both in returns and volatilities. Such links have been stressed by existing literature based on in-sample evidence, yet, there has been no empirical study to suggest whether oil price volatility improves real out-of-sample forecasts of food price volatility.

Thus, given the weight of in-sample evidence from a number of studies pointing to the important role of oil price volatility in commodity price volatility, we utilise out-of-sample forecasting techniques in order to investigate whether oil price volatility has any incremental predictive information with regard to food price volatility.

To do so, we focus on five key food commodities, namely, corn, rough rice, soybeans, sugar #11 and wheat, as well as, the two main crude oil benchmarks, i.e. West Texas Intermediate (WTI) and Brent for the period January, 1990 to March, 2017. In the interest of comparison, we employ predictive models with and without the information from the oil market (i.e., oil volatility). In particular, we initially employ the Heterogenous Autoregressive (HAR) model by Corsi (2009) on monthly volatility, which we augment with oil price volatility (HAR-X). We further enhance our modelling approach by considering a mixed-data sampling model (MIDAS) so to assess whether the incremental predictive information of oil price volatility on monthly food price volatility forecasts can be hidden in higher frequency (i.e. daily oil price volatility, MIDAS-HAR- X). For robustness, we use three volatility measures, namely, realized volatility, price range volatility and realized range volatility. We produce real out-of-sample forecasts for 1- up to 12-months ahead for the period January, 2000 up to March, 2017 (i.e. 207 months)

Our findings suggest that the oil price volatility-enhance models cannot systematically outperform the standard version of the HAR model that excludes information stemming from the oil market. In point of fact, any improvement that occurs in the out-of-sample forecasting of monthly food price volatility, based on the HAR-X or MIDAS-HAR-X models, is sporadic, despite the fact that the in-sample analysis suggested that the performance of the MIDAS-HAR-X models is superior compared to the standard HAR model. What is more, these findings hold irrespective of the crop, forecast horizon, volatility frequency or the type of oil market that is studied. These findings remain robust to (i) alternative volatility measures (realized volatility, price range volatility and realized range volatility), (ii) forecasting averaging techniques, as well as, (iii) analysis during turbulent periods, such as the food crises of 2007–2009 and 2010–2012, as well as, the oil price collapse in 2014–2016.

The Choice between Renewables and Non-renewables: Evidence from Electricity Generation in 29 Countries

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For decades, electricity has been the fastest growing form of global end-use energy consumption globally. To achieve the environmental goals set out in the Paris Agreement, both developed and developing nations are undergoing transitions in the composition of their energy mixes and

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making efforts to increase the role of renewable energy sources, while balancing these with concerns regarding continued economic growth.

We investigate the effects of rising income and changes in relative prices on the usage of renewable and non-renewable energy sources in electricity generation using a dataset comprising 29 countries over the last three decades (1985-2017). Adopting the panel version of the fully modified ordinary least squares (FMOLS) method, we empirically analyse the income elasticities of energy usage for major primary energy sources: oil, coal, natural gas, nuclear, hydroelectric, as well as other renewable sources (including wind, solar, and geothermal), and explore complementary and substitution effects across various energy sources.

For developing nations, we find that while rising income is associated with significant increases in usage of all primary energy sources in electricity generation, the increase of greatest magnitude is for renewable sources. As for developed nations, increasing income is not necessarily associated with a significant rise in the use of nuclear or hydro for electricity generation. Comparing developing to developed economies, we find that developing nations have a higher income elasticity for all primary energy sources than do high-income countries.

With regards to renewable and non-renewable sources for electricity generation, the results indicate that the complementarity or substitutability of energy sources vary from developed to developing nations and the trade-offs are not simply between renewables and non-renewables. Nonetheless, there are some consistencies across income groups: oil is consistently used as a substitute for other fossil and non-fossil fuels except nuclear. Natural gas (as a transitional fuel) is a complement for oil and other renewables in both developing and developed economies.

Our analysis provides insight into the nature of 'energy ladder' behaviour that economies have historically exhibited in electricity generation. As policy makers plan and manage energy mix transitions towards zero emission systems, our study provides insights into feasible substitutions appropriate for both developing and developed nations.

Buyer Beware: The Asymmetric Impact of the Strategic Petroleum Reserve on Crude Oil Prices

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The Strategic Petroleum Reserve (SPR) was created in response to the 1973-1974 oil embargo by the Organization of the Petroleum Exporting Countries, and was intended to reduce the impact of petroleum supply disruptions on the U.S. economy. The theory that motivated the creation of the Reserve is simple: the government could offset supply disruptions by increasing oil supply with the SPR rather than by restricting oil demand with unpopular quotas, tariffs, or taxes. Since research was beginning to connect oil price increases in the 1970s with the subsequent economic downturns, a policy mechanism that controlled oil prices had broad political appeal.

We use data on purchases and releases from the SPR since the early 1980s to determine whether U.S. oil market policy interventions through the SPR succeeded in lowering the price of crude oil. We show in a structural VAR model with recursive timing restrictions that an unanticipated SPR release has no measurable effect on oil prices, while an unanticipated SPR purchase increases the price of oil by 1 percent over 20 weeks following purchase.

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We also explore alternate identification methods for SPR policy using information that is not contained in the VAR model. To identify the impact of SPR purchases on oil prices, we construct an instrument for SPR purchases from the purchase schedules set by the Department of Energy. These schedules are set months ahead of actual purchases, making them exogenous with respect to other oil market shocks at the time of purchase. This instrument identifies SPR purchase shocks in the VAR framework without other restrictions on the structural shocks. An unanticipated SPR crude oil purchase, identified with the purchase schedule, increases the price of crude by approximately 2 percent over 20 weeks following purchase.

We use a different model to identify the effect of SPR releases with high-frequency crude oil futures market data. The change in crude oil futures prices in the 30 minutes following release announcements is used to measure whether SPR releases are unanticipated by the market. Estimating policy shocks with this method avoids problems with endogeneity and omitted variables that have been raised concerning policy shocks estimated in traditional VAR models. This model shows that unanticipated SPR releases do not have a statistically significant effect on oil prices.

The main contribution of this paper is developing a framework to estimate the impact of U.S. oil market interventions on oil prices. We show that, under a variety of identifying assumptions, SPR releases have not lowered the price of oil, while SPR purchases have increased its price.

The Effect of Human Capital on CO_2 Emissions: Macro Evidence from China

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Rapid accumulation of carbon dioxide (CO_2) has alarmed the catastrophic consequences of global warming. Despite the collective efforts by international communities, the potential of growing CO_2 emissions remains strong. As the top CO_2 emitter in the world, China and its strategy and path toward CO_2 abatement have attracted considerable attention in both policy and academic circles. While promising, the abatement target pledged by the Chinese government is also ambitious. To cut carbon intensity by 60 to 65 per cent from the 2005 level before 2030, China needs to reduce it annually at 4.2 per cent which is above the pre-2014 rate (1.49 per cent) by almost three percentage points.

Until now, a conventional solution like command-and-control remains the fundamental tool for the Chinese government to reduce various emissions. Their limited effect, however, is generated at the expense of substantial economic losses along with the unwanted market distortion at the regional level. Given China is an authoritarian state still riddled with red tape, the efficiency and effectiveness of those regulation-based tools are further constrained. Their market-based counterparts are expected to fill the void. However, available instruments like carbon tax and emission trading scheme (ETS) are still at the early stage and yet to be fully implemented, making their efforts on abating CO_2 emissions marginally at best.

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With this backdrop, we examine whether investing in human capital could be used to facilitate carbon reduction without distorting economic growth much. We do recognize that human capital is not necessarily the only or the most important way for abating carbon emission. Nevertheless, we believe this study improves our understanding of social benefits associated with human capital accumulation, extending them to the perspective of environmental protection.

We take the advantage of recently-released CO_2 emissions data and construct a provincial panel spanning the period 1997–2016 to study the association between human capital and CO_2 emissions. We perform regression analysis and find a negative and significant association between human capital and CO_2 emissions. Importantly, since we have employed a set of human capital proxies differed by age and qualification, we are able to reveal heterogeneous human capital–CO_2 emissions nexus. We show their negative association is due to human capital embodied in workers aged between 25 to 44 and workers with tertiary education. Finally, we analyse mechanisms underlying our established results using disaggregated CO_2 emissions by energy sources and end emitters. We find the negative association is manifested through technology effect and the improvement in energy efficiency. These mechanisms are limited to the production sector and are absent in the household sector.

Our finding suggests a promising avenue for abating carbon emissions without impeding economic growth. Specifically, schools may consider teaching long-term impacts associated pollutions to improve students' environmental awareness from the very beginning. On the production side, financial incentives should be offered to enterprises which provides energy/environment related training to their employees. For those firms in high energy/pollution intensity industries, they should recruit more professionals to innovate their production practices toward an environmentally-friendly way. Although this study finds that human capital fails to reduce pollution in the household sector, it points out an avenue for the Chinese government to exert more efforts. For instance, the public campaign should be promoted to strengthen households' environmental awareness which cautions them from damaging the environment. Meanwhile, the financial incentive should be placed on encouraging renewable energies or energies with less environmental impacts.

Quantifying the Distributional Impact of Energy Efficiency Measures

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Energy efficiency programmes often pursue two objectives simultaneously: reducing emissions and combating fuel poverty. As a result questions of distribution and equity are becoming increasingly important both for academics and policymakers. Quantifying where the costs and benefits fall can provide greater insight into the equity and cost-effectiveness of government policies, and improve our understanding of household investment decisions.

We exploit a large database of home energy efficiency upgrades and metered energy consumption to provide new evidence of the distributional impact of energy efficiency measures. The analysis focuses on measures installed through the UK Supplier Obligations, the principal policy instrument for delivering energy efficiency measures in the UK and widely used in other European countries. The research draws on the National Energy Efficiency framework Database (NEED),

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which holds information on metered gas and electricity consumption for over four million households and a period of eight years.

We employ a range of statistical and econometric tools to answer the following questions: (i) how much savings do key energy efficiency measures actually deliver? (ii) do savings vary by level of household deprivation and (predicted) income? (iii) do the observed differences persist over time (iv) can our findings be explained by differences in baseline consumption? And finally, (v) What do our results imply for the relative cost-effectiveness of measures?

Results suggest that savings vary considerably by measure installed and level of household deprivation. These difference persist over time, and there is some evidence of an erosion of savings over time for loft insulation and heating system replacement. Differential baseline energy consumption is a factor but only partially explains the results. The measure are still largely cost-effective but much less so than previous ex-ante evaluations would suggest.

Overall, our results provide new evidence on the distribution of savings realised across households and over time. At an individual household level, the private benefits of energy efficiency measures need to be reconsidered, with a greater focus on the non-financial benefits. The total welfare gains from upgrades to more deprived households may be considered greater if those households place more importance on increased internal temperatures and any resultant improvements to health and wellbeing than on energy and cost savings. At a societal level a greater focus on reducing carbon emissions, as opposed to cost-savings, is required.

Economic and Environmental Consequences of Market Power in the South-East Europe Regional Electricity Market

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Two major historic processes of the last four decades have shaped current electricity markets worldwide. First, the unbundling of vertically integrated utilities resulted in imperfectly competitive electricity markets. Second, concerns about greenhouse gas emissions led to carbon pricing through transferable property rights, e.g., allowances or permits. As with any other market, that for carbon allowances can be subject to the exercise of market power.

We investigate the economic and environmental effects of market power on electricity and permit markets in regional electricity markets where participants are not all subject to the same CO_2-emission-reduction policies. An example is the South-East Europe Regional Electricity Market (SEE-REM), which comprises both EU members subject to the emission cap of the EU Emissions Trading System (ETS) and non-EU members exempt from such a cap. Towards that end, we examine how a dominant firm can (i) gain an economic advantage and (ii) affect carbon leakage by manipulating both the electricity and permit prices.

We use a game-theoretic model with firms, consumers, and an independent system operator (ISO). Each firm owns several plants and maximises its profit via its production, while consumers are represented by nodal inverse-demand functions. The ISO determines the welfare-maximis-

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ing imports/exports at each node. The case study is based on data from the year 2013 comprising transmission capacities, generation capacities, hydropower availabilities, and seasonal demand. The electricity market is cleared by equating nodal net supply and demand, and the price of CO_2 emissions is determined endogenously through a binding constraint on emissions from ETS units. Since we investigate the effect of market power in both electricity and permit markets, we have (i) a baseline perfect competition model [PC], (ii) a bi-level model with a Stackelberg leader that manipulates only the electricity prices taking the PC permit prices as given [S-T], and (iii) same as (ii) except that the Stackelberg leader manipulates both the electricity and permit prices [S].

In each of the three market settings, we impose emission-reduction scenarios varying from no cap on ETS emissions to a 40% reduction on ETS emissions. Under [PC], a binding cap on ETS emissions curbs ETS production. As the cap tightens, the price differential between ETS and non-ETS areas of SEE-REM increases, thereby enticing non-ETS production and leading to higher non-ETS emissions. Consequently, there is carbon leakage between 39%-11% for caps of 10%-40% reduction, respectively, compared to the baseline. The leader's strategy under [S-T] changes with the stringency of the environmental regulation. When natural gas is the marginal technology, which occurs at lower carbon-tax levels, the leader withholds production from its dominant technology (coal) in order to raise electricity prices. Higher electricity prices entice ETS natural-gas (including the leader's) and non-ETS production, which partly replaces the share vacated by the leader's coal plants. As a result, ETS (non-ETS) emissions fall below (rise above) the corresponding [PC] level. Since the reduction in ETS emissions offsets the increase in non-ETS emissions, carbon leakage is lower under [S-T] vis-à-vis the corresponding [PC] setting. For a carbon tax such that coal reaches cost parity with natural gas, the leader conversely expands coal production in order to set equilibrium prices. Higher electricity prices entice ETS coal and non-ETS production resulting in ETS and non-ETS emissions as well as carbon leakage above the [PC] level. Under [S] with a modest emission cap, the leader holds back more coal compared to that in [S-T] in order influence the permit price. A lower abatement cost results in higher ETS natural-gas production and ETS emissions compared to those in the corresponding [S-T] setting leading to higher carbon leakage. When coal reaches marginal-cost parity with natural gas under a more stringent cap, the leader expands coal to a lesser extent compared to that under the corresponding [S-T] setting as it does not want to increase the permit price. Contrary to [S-T], since the ETS fringe cannot increase coal production because of the cap, it increases natural-gas production. This leads to lower ETS emissions and carbon leakage vis-à-vis the [S-T] setting. Generally, the leader reaps higher profits when it has the ability to manipulate both markets. Hence, understanding the incentives of such a dominant firm is pertinent to devising EU carbon policy.

Do Energy Efficient Firms Have Better Access to Finance?

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Improving energy efficiency quickly is key to mitigating climate change and a large part of such improvements has to be implemented in firms. But since most energy efficiency improvements require upfront investments, good access to external finance is important. Theory suggests

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that information asymmetries may prevent lenders from including energy efficiency into their lending assessment, even though higher energy efficiency makes a firm more cost-competitive and its collateral worth more, especially if stringent climate change mitigation plans are implemented.

Empirically, little is known about the impact of energy efficiency on access to external finance. Here we examine for the first time empirically the effect of a firm's higher energy efficiency on its ability to obtain loans in European Union countries. We exploit a unique firm-level dataset that links a survey from the European Investment Bank on energy efficiency of firms' building stock and on access to external finance with the ORBIS firm database for firms in all EU countries.

We find that energy efficiency has no effect on the ability of a firm to obtain external financing compared to other indicators and characteristics of the firm. These include whether the firm is foreign-owned, its size, and its age. Indicators on the financial health of the firm are its current ratio, return on assets, and financial leverage, whereas those on its operational health are innovation, labour productivity, state-of-the-art machinery, investment in R&D, and whether the firm is operating at full capacity. Thanks to the rich dataset, these variables are included in the empirical estimation. Additional analysis using information on past energy audit, the firm's regional location and whether it is in the eurozone confirms the result.

The results have important policy implications, as they reveal an unexploited potential for energy efficiency policy to signal when firms are energy efficient. If energy efficiency does not lead to better access to finance, or if firms that want to implement such measures cannot finance them cheaply, this can slow down overall progress on energy efficiency. Whereas energy efficiency assessment as part of the lending process and compulsory energy audits are already in place, we find that currently, these audits seem to have no signalling effect on granting firms better access to finance, and that firms that are likely to be under scrutiny when banks lend to them are large firms, which tend to have better access to finance anyway. Scope therefore exists for policies focusing on facilitating energy efficiency financing, which are currently implemented only by 10 out of 28 countries in the EU, and which, if implemented successfully, could lead to a "triple win situation": for the banks, firms, and the effort at mitigating climate change.

A Retrospective Evaluation of the GDF/Suez Merger: Effects on the Belgian Gas Hub

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Competition policy enforcement activity in the EU energy sectors has increased significantly over the last fifteen years, especially with regards to merger cases. In some of its decisions, the European Commission (EC) required merging parties to offer substantive remedies to, in principle, offset the anti-competitive effects of the merger (see e.g. Polemis, 2018).

In reality, though, some of these remedies may have gone further than that. Indeed, many commentators have argued that they may have been used to promote market liberalisation and in particular to achieve effective unbundling of network and supply activities.

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This paper provides a quantitative ex-post analysis of one of the most important mergers in the EU energy sector in recent decades, the Gaz de France's (GDF) acquisition of Suez in 2006. We analyse whether the merger and the associated remedies imposed by the EC restored, or indeed improved, initial market outcomes.

We focus on the impact on the market for trading in Belgium's Zeebrugge (ZEE) hub, a key part of the European gas market and an important target of the remedies imposed by the EC. Indeed, prior to the merger, the ZEE hub had suffered from limited infrastructure access and liquidity issues. Part of the remedies, which included ownership unbundling, aimed to free up access to the hub. If effective, the remedies should allow for a higher liquidity through more entry, higher traded volumes, and lower prices in the hub.

We present a series of Difference-in-Difference (DiD) analyses, which compare the evolution of prices at the ZEE hub relative to different counterfactual hubs before and after the merger, suggesting that the remedies did more than successfully limit the merger's potential anti-competitive effects. Indeed, we find that not only did prices not increase, but they declined. We also provide evidence of the improvement of other outcomes at the ZEE hub in the post-merger period in terms of increased entry, trading volumes and investment.

Our analysis supports the view that the EC's merger policy actions may have been used as tools to improve market outcomes in EU energy markets. One cannot totally exclude that price declines are a consequence of some efficiency gains generated by the merger. However, this is unlikely, given that no potential efficiency gains at the hub were indicated by the merging parties. The estimated decline in prices, thus, suggests that ownership unbundling has generated better access to the hub. In this respect, the remedies seem to have done more than simply mitigate the potential anti-competitive effects of the merger.

Our results are also in line with the view that for merger transactions that fall within its jurisdiction, the EC can bypass Member States in applying EU merger policy in order to reduce the power of national champions. Indeed, through the application of merger remedies, the EC can ensure third-party access and unbundle vertically integrated companies. These remedies may at first sight seem like an overreach of limiting potential anti-competitive effects. However, the European Court of Justice pointed out in its judgment of ENI/EDP/GDP merger that there exists no legal problem to the EC pursuing liberalization of energy markets through its merger policy actions, as it is aimed at increasing competition.

Exogenous Oil Supply Shocks in OPEC and Non-OPEC Countries

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Recent geopolitical events, such as the 2019 drone strikes targeting Saudi Arabian oil-processing facilities and growing tensions between the U.S. and Iran, have refueled public concerns about oil supply disruptions. At the same time, there is an ongoing debate in the academic literature about how to identify oil supply shocks in structural vector-autoregressive (VAR) models of the global oil market, arising from different views about the short-run price elasticities of world oil supply and demand. This calls for external instruments in order to identify the dynamic causal effects of exogenous oil supply disruptions on world oil prices and macroeconomic conditions.

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Kilian (2008: "Exogenous oil supply shocks: How big are they and how much do they matter for the U.S. economy?" *Review of Economics and Statistics* 90(2), 216–240) proposes a measure of oil supply shocks based on arguably exogenous production shortfalls in OPEC countries due to geopolitical events such as wars, strikes or natural disasters. Production shortfalls are constructed as the difference between the actual production levels and a country-specific counterfactual based on the evolution of oil production in a benchmark group of countries that was not subject to the same or any other exogenous event during the period under consideration but adhered to similar economic conditions – in particular the same crude oil price – and incentives.

We expand Kilian's (2008) original series of exogenous oil supply shocks along two dimensions. First, we extend the sample period to include production shortfalls in OPEC countries also during 2004:10–2019:12. Second, we consider production shortfalls in major oil-producing countries outside of OPEC, including the U.S. and Canada, for example. These two extensions yield a truly global measure of exogenous oil supply shocks at the monthly frequency for 1973:1–2019:12.

Our time series displays statistically significant contemporaneous correlation with state-of-the-art estimates of oil supply shocks based on structural VAR models. At the same time, it requires only a limited number of explicit assumptions about the counterfactual oil production in the countries under consideration and provides thus an alternative to and instrument for the estimates based on structural VAR models.

Given that the methodology in Kilian (2008) relies on the identification of arguably exogenous political events and natural disasters, the resulting time series predominantly reflects negative oil supply shocks. However, these are exactly the kind of production disruptions that are of primary interest to market participants and policymakers alike, as they are likely to cause an unpredictable increase in the price of crude oil.

Systemic Risk for Financial Institutions in the Major Petroleum-based Economies: The Role of Oil

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The oil rich countries, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE of the Gulf Cooperation Council (GCC), are heavily petroleum-dependent economies that are underpinned by huge foreign assets and powered by foreign labor. The oil dominance in these countries implies that a marked change in the level of oil prices will significantly affect all the sectors of their economies and may exacerbate their financial systemic risk, thereby harming the stability and the functioning of their financial sectors. In turn, the harm could have further negative consequences for the cyclical sectors. Notably, these countries attempt to coordinate their policies to achieve their common goal of realizing full economic integration through the GCC. Within such a business environment that is characterized by heavy oil dependence, high financial interconnectedness and strong propagation of risk, the examination of the risk tolerance of GCC financial institutions to oil price and volatility movements presents itself as an interesting case study, particularly in the wake of the recent global financial crises and the recent reoccurrence of the collapses in oil prices. For this reason, this paper attempts to address two major questions related to the financial sectors of those petroleum-exporting

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economies, which possess large foreign assets but are still vulnerable to oil price risk. First, do oil shocks cause stress to petroleum-based financial institutions? Second and more relevant, what is the impact of the movement of the level of oil prices on the systemic risk indicators for those financial institutions? To investigate the impact of oil price variations on a GCC financial institution's systemic risk, we have collected data on the stock prices for the financial companies as well as on the levels of national market indexes for the GCC area for the period from March 2004 to November 2018. Building on these data, we proceed to the estimation of the systemic risk measure proposed by Adrian and Brunnermeier (2016), the ΔCoVaR. By estimating ΔCoVaR, we observe the presence of remarkable increases in risk levels during the financial crises and achieve a better risk measurement when oil returns are included in the risk functions. Moreover, the estimated spread between the CoVaR without and with oil returns is absorbed in a time range that is longer than the duration of the oil shocks. This indicates that drops in oil prices have a longer effect on risk and financial institutions and require more time to account for their impact. From a policy perspective, our study indicates that oil price movements must clearly be considered when focusing on systemic risk measurement, monitoring and management in those petroleum-based economies. Neglecting the oil price in the set of state variables and excluding its long-lasting impact at least up to one month, will lead to an incorrect measurement of the systemic risk impact for financial companies, and hence on their financial stability. Our findings provide new evidence about the impact of oil shocks on the GCC financial system and have a clear implication for risk management regarding the protection strategies in the portfolios based on this market.