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Energy intensity and environmental performance in the Gulf Cooperation Council region: a heterogeneous panel approach

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Abstract

While the six Gulf Cooperation Council (GCC) countries are among the most energy-rich in the world, they face unsustainable growth in energy use and environmental degradation. This paper examines the long-run relationship between per capita CO2 emissions and energy intensity in the GCC, while controlling for economic activity, the size of the manufacturing sector, and differences in institutional qualities. We use heterogeneous panel techniques that account for cross-country dependence for the period 1971-2010. We find that energy intensity and emissions are cointegrated in all GCC countries and that conservation and energy efficiency policies have greater potential in reducing emissions in Kuwait, Oman, and the UAE. However, energy efficiency and conservation *alone* may not be viable policy options to significantly cutting emissions in the next decades. A regional goal of mitigating emissions by 10% would require a reduction in energy intensity by 12%, on average. Therefore, investing in Carbon Sequestration (CS) technologies and strong commitment to renewable energy seem essential ingredients to any sustainable energy and environmental strategy. In addition, we find that judiciary independence is an essential institutional quality for the successful implementation of long-term environmental policies.

Keywords: Sustainability, Emissions, Energy intensity, Heterogeneous panels, GCC.

JEL code: Q01, Q42, Q48, Q56

Energy intensity and environmental performance in the Gulf Cooperation Council region: a heterogeneous panel approach

1. Introduction

In light of the international agreement on the risks of climate change, most countries around the globe have been under growing obligations to reduce greenhouse gas (GHG) emissions. Reducing energy intensity through improving energy efficiency and the rational use of energy (RUE) has become an attractive policy option to slow down CO2 emissions growth. This paper investigates the long-run relationship between per capita CO2 emissions and energy intensity in the Gulf Cooperation Council (GCC) countries to draw some policy insights for the region and on the country level. In particular, it asks the policy question of whether conservation and energy efficiency policies are viable policy options to bringing emissions to sustainable levels in the next few decades.

The GCC region, including Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates (UAE), is among the most energy-rich in the world. The six states have experienced a tenfold growth in energy use and electricity generation since the late 1970s (Fig. 1). In addition, because the energy mix is almost fully dependent of fossil fuels, the exponential surge in energy demand has been associated with an alarming degradation in environmental quality. Both energy and environmental trends are deemed unsustainable in the long-run.

According to the International Energy Agency (2012)[1], the six GCC countries rank among the top 15 CO2 emitters (in per capita terms) in the world. In light of the GCC states' ratification of the Kyoto protocol (in 2005 and 2006) Table 1 demonstrates the need for policy actions aiming to limit GHG growth. In 2010, the GCC region emitted more than four times the world's average in per capita terms and had one and a half times the world's emissions intensity. While Bahrain and Saudi Arabia have the highest carbon intensity per unit of output, Qatar and Kuwait have the highest emissions per capita. Fig. 2 shows that, with the exception of Bahrain and Qatar, energy intensity steadily increased in the past four decades, indicating larger average energy use per unit of output. This trend has been associated with similar developments in per capita CO2

[1] CO2 Emissions from Fuel Combustion Report, 2012.

emissions which triggers the question of to what extent reducing energy intensity would help improving environmental performance in the region in the long-run.

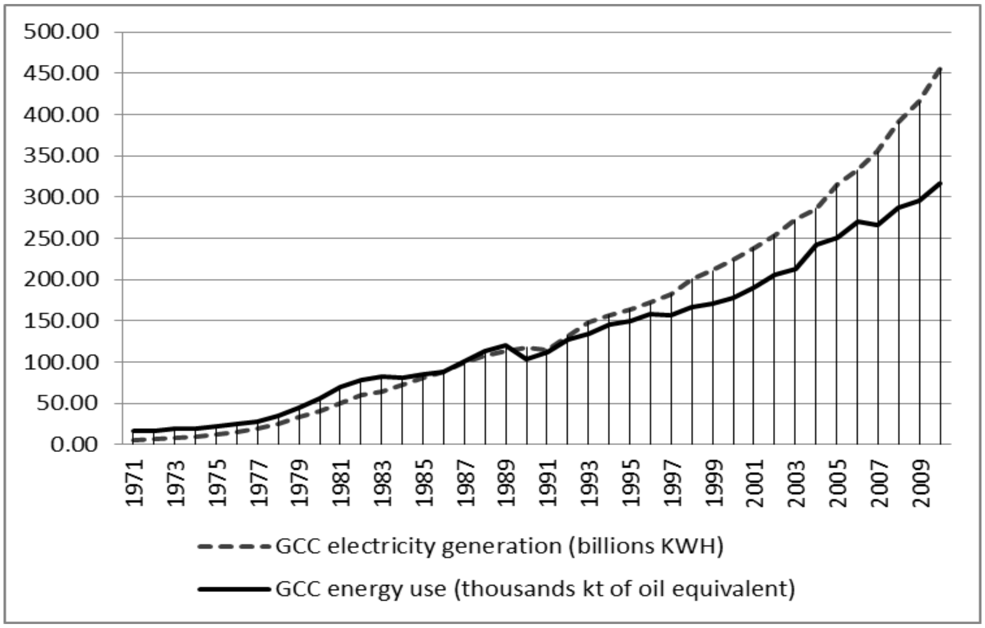

Fig. 1: GCC energy use and electricity generation growth (1971-2010)

Source: World Development Indicators 2012

Table 1: CO2 emissions in the GCC region in 2010

	Energy[1] subsidies (%GDP)	Metric tons[2] CO2/capita	kg. CO2 per unit of GDP[3] (2005 USD)
Bahrain	8.20%	18.71	0.88
Kuwait	7.40%	31.93	0.71
Oman	6.10%	14.47	0.59
Qatar	3.70%	36.90	0.48
Saudi Arabia	9.80%	16.25	0.80
United Arab Emirates	5.80%	20.50	0.48
GCC[3]	7.61%	18.76	0.66
World	0.70	4.44	0.44

Sources: 1. IMF (2012)
2. International Energy Agency (2012)
3. Authors' calculations

Despite these growing environmental concerns, environmental and energy efficiency policies remain incoherent and not tied to clear long-term strategies. Some GCC countries, however, have proactively started pursuing some ecological modernization policies through the promotion of renewable energy sources. The Masdar initiative in Abu Dhabi is one important example. But these individual efforts have not yet resulted in the development of consistent strategies and policies (Reiche, 2010). In addition, the region still lacks vital sustainable energy investments in the development of carbon sequestration (CS) technologies and RUE policies (Patlitzianas et al, 2007).

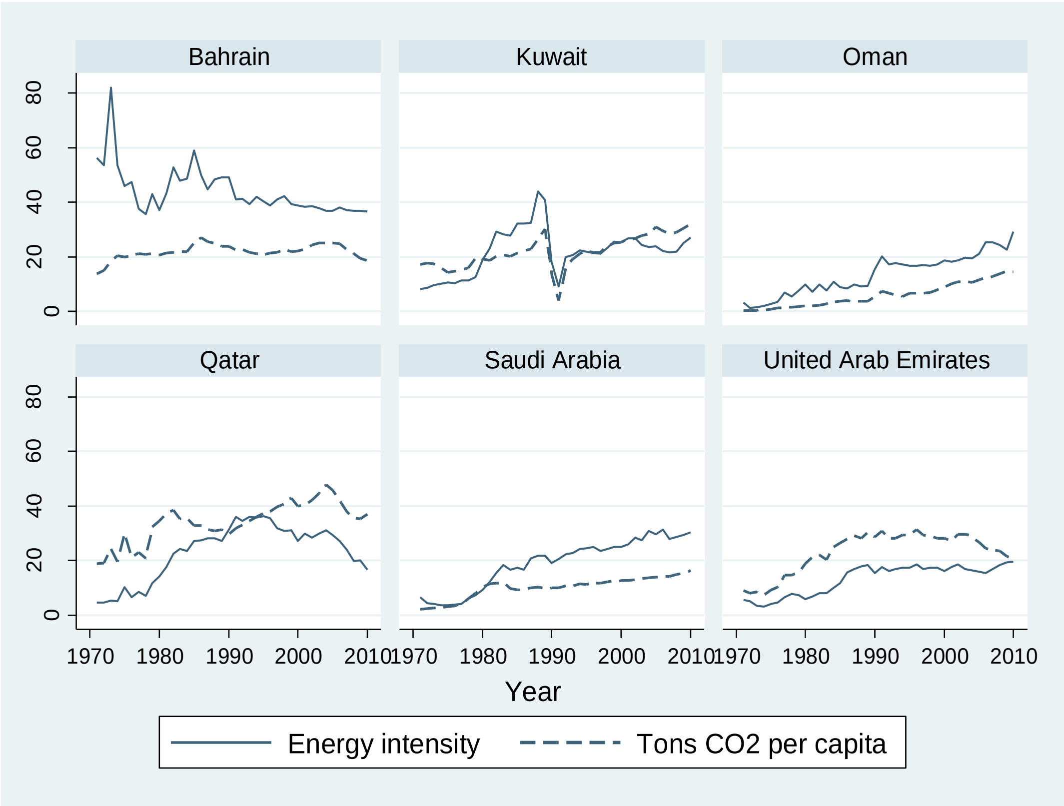

Fig. 2: CO2 per capita and energy intensity per $100 (2005 USD ppp)

Source: International Energy agency, 2012

The objective of this paper is to estimate the long-run relationship and the short-run adjustment dynamics between energy intensity and environmental performance, measured by the level of per capita CO2 emissions. We account for three important developments in the past three decades. First, the gulf countries have placed high priority on economic diversification policies, especially manufacturing, in order to reduce the dependence on oil. Second, the region has witnessed a tremendous growth in economic activity, manifested in significant growth in per capita incomes. Third, there have been significant changes in various governance and institutional qualities that may be directly linked to the credibility and enforceability of energy and environmental policies.

We employ recent panel cointegration and unit root techniques that account for both heterogeneity and cross-section dependence in the GCC region, for the period 1971-2010. These techniques also have the advantage of increasing power by utilizing the panel dimension of the data, while allowing for country-level insights.

The rest of this paper is structured as follows. In section two, we discuss the GCC energy efficiency challenges and the related literature. Section three presents the empirical model, data, and econometric methodology. In section four we discuss the results, highlighting the main policy implications. Section five concludes.

2. Background: GCC Energy and Environmental Performance

Enhancing energy efficiency and improving environmental performance in the GCC countries is very challenging. Spiess (2008) argues that socio-political and institutional factors may undermine the ability of the gulf region to adopt effective climate change policies. These factors contribute to the toleration, or even the promotion, of policies that "support a wasteful and environmentally destructive use of resources" p.245. In this regard, at least two policy-related issues can be spotted.

First, the lack of environmental standards; there is the usual concern that adopting standards targeting the environmental performance of firms and industries would hinder economic diversification and halt growth. Second, the GCC countries heavily subsidize the petroleum products and electricity for both household and industrial uses. Table 1 indicates that in 2010 the GCC area had exceeded ten times the world's total energy subsidies relative to GDP.[2] This amounts to 20% of total world energy subsidies (IMF, 2012).[3] These subsidies have many negative implications such as the excessive use of energy, the misallocation of resources towards energy-intensive industries, and the distortion of incentives to invest in renewables. Patlitzianas et al (2007), identify GCC governmental electricity subsidies as the main obstacle to expand investments in energy efficient photovoltaic road lighting and solar-cooling systems.

Despite these challenges, actions to reduce GHG to acceptable levels and to reform energy policies in the GCC became inevitable. Energy price reforms are a top priority. Studies find that deregulating energy prices reduces energy intensity. In China, for instance, energy intensity fell consistently over time in the period 1985–2004 after the deregulation of energy prices (Hang and

[2] Author's calculations based on IMF (2012) report.
[3] Note that the GCC countries contributed less than 2% in the world's total output in 2010.

Tu, 2007). Similarly, energy intensity declined in transition economies after the liberalization of energy prices in the 1990s (Cornillie and Fankhauser, 2004).

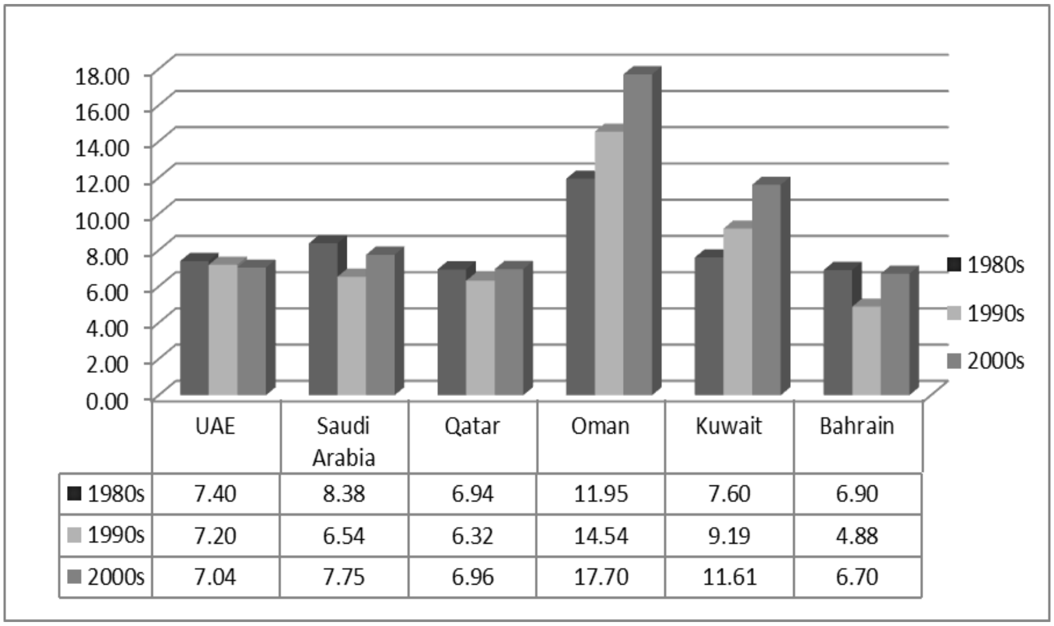

Fig. 3: Electric power transmission and distribution losses (% of output)

Source: World Development Indicators 2012

Qader (2009) finds that electricity generation from fossil fuel sources is the major factor contributing to the growth of GHG in the GCC; hence, the expected environmental gains from improving efficiency can be quite significant. Maruyama and Eckelman (2009) compare the efficiency of power generation across regions in the world and find that the Middle East trails behind OECD and other non-OECD countries. In addition, while natural gas power plants are usually more energy efficient than oil or coal plants, thanks to the combined-cycle (natural gas and steam turbines) technology, the study finds that oil-fired power plants are more energy efficient than natural gas plants in the Middle East. This, however, implies that improving efficiency in gas-powered electricity plants has good potential in curbing emissions; Qatar is a good example discussed below.

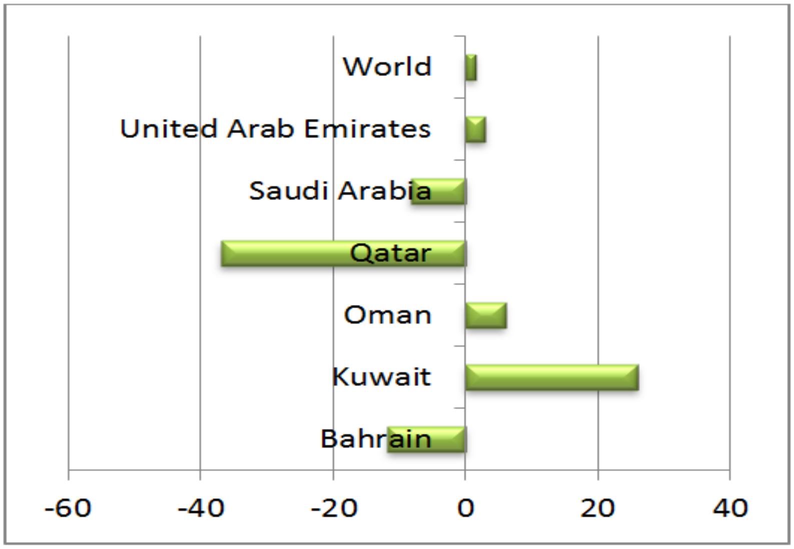

Fig. 4: Growth of CO2 emissions from electricity generation (%) between the 1990s and 2000s

Source: Author's Calculations from International Energy agency 2012 data

In addition, the high rates of electricity transmission and distribution losses in the GCC countries signal great potential for energy efficiency policies. Fig. 3 shows that Oman and Kuwait have witnessed steady increases in energy waste since the 1980s and have had the highest transmission and distributional losses which roughly reached 18% and 12%, respectively, in the 2000s. These trends have significant consequences on the environment. The only country showing a declining trend in transmission losses in the past three decades is the UAE (El Anshasy and Hatemi-J, 2013). Saudi Arabia and Bahrain show significant improvements in electricity efficiency in the 1990s, but this trend is reversed in the 2000s. Confirming the environmental impact of these trends, Fig. 4 shows the growth in emissions from electricity generation between the 1990s and the 2000s. Kuwait and Oman witnessed a significant increase in emissions from electricity that reached about 25% and 8%, respectively.

Qatar stands out with a significant reduction in emissions from electricity generation by about 38% (Fig. 4). Despite a net growth in electricity generation and no significant change in transmission and distribution losses, the decline in emissions was due to a full switch to natural gas-power generation that utilizes enhanced combined-cycle technology which combines power generation and water desalination and is significantly more energy efficient.

Hertog and Luciani (2009) argue that energy efficiency and conservation policies that target large-scale projects have more potential in the GCC than broader regulatory strategies that aim to change consumer and business behavior. Similarly, Reiche (2010) emphasizes that the GCC states should adopt ecological modernization strategies that entail transforming their oil wealth into investments in renewable energy and energy efficiency.

On the country level, Kazim (2007) highlights the unsustainable energy consumption and emissions paths in the UAE, emphasizing the need to devise energy management programs in various sectors and utilize renewable sources. Alfarra and Abu-Hijleh (2012) also emphasize the importance of improving electricity efficiency in the UAE and argue that nuclear energy demonstrated economic viability in electricity generation. Hepbasli and Alsuhaibani (2011) find that the switch to solar energy can substantially reduce Saudi Arabia's energy consumption of fossil fuel and GHG emissions. In Kuwait, Alotaibi (2011) argues that there is a growing supply shortage in electricity generation due to "significant waste and over-consumption of energy". He finds that Kuwait consumes more than 20% of its energy production and that is expected to reach 40% by 2015, resulting in major environmental degradation. He advocates more efficient electricity generation, the modification of existing power plants, and the transition to solar and wind energy.

In a different vein, studies on the growth-energy nexus applied to energy-exporting economies indicate that causality runs from economic growth to energy consumption and not vice versa, suggesting that the presumed negative growth effect of energy conservation policies is overstated. Al-Iriani (2006) confirms this unidirectional relation from growth to energy for a panel of GCC countries. Similar insights can be drawn on the country-level from Squalli and Wilson (2006). Their findings support electricity conservation policies in five out of the six GCC countries. Mahadevan and Asafu-Adjaye (2007) find a similar result for ten net energy exporters. Mehrara (2007a and 2007b) reaches a similar conclusion for Iran and Kuwait and a panel of eleven oil-exporting countries, respectively. The only exception to this result is Mehrara (2007a) who finds energy causing growth in the case of Saudi Arabia.

In addition, even though high fossil fuel use has been a driver for growth in many nations, this is not expected to hold in the future. Many researchers and experts maintain the view that the world is moving towards the so called 'new low-carbon energy-industrial revolution' that would result in a transition to low-carbon growth paths. The 'green race' is expected to bring about new ideas, innovation, investment opportunities and employment that will allow participating nations to enjoy higher growth with lower emissions. Contrarily, maintaining high-carbon growth can only be self-destructive; nations left behind will likely be perceived as 'dirty" and will risk losing their trading partners, being driven out of important markets, and suffering growth deterioration (Costantini and Martini, 2011; Stern and Rydge, 2012; Fankhauser et al, 2012; El Anshasy and Katsaiti, 2014).

In sum, evidence from previous studies suggests that GCC countries should adopt energy efficiency and conservation policies to curb GHG growth. Studies also emphasize the importance of changing the energy mix away from fossil fuel sources. The current study is an attempt to verify these important policy implications for the six countries of the GCC.

3. Empirical Model, Data and Methodology

The objective of our empirical analysis is to test, and then estimate, a long-run equilibrium relationship between CO2 emissions and energy intensity in the GCC region. We control for three important factors; (i) an increasing economic activity; (ii) a policy emphasis on diversification and manufacturing; (iii) improvements in institutional qualities.

Therefore, we consider a multivariate model of carbon emissions; CO2= f (S, y, I, E). Where, per capita CO2 emissions is determined by four factors: (i) the structure of the economy, S, represented by the manufacturing sector's share in GDP, (ii) the level of economic activity, y, measured by per capita real GDP; (iii) the quality of institutions, I, represented by a number of indexes (see below), and (iv) energy intensity, E, measured as energy use per unit of real GDP. Table 2 lists all variables and their sources. The data cover the period 1971-2010.

Better institutions are expected to improve environmental performance and reduce the environmental cost of economic growth (Panayotou, 1997). Since institutional quality indexes mirror various governance aspects and may arguably affect emissions in different ways, we employ four different indexes that we find available (see Table 2 for a definition of these indexes). Socially fragmented countries often suffer from low levels of cooperative social behavior and under-provision of public goods, including environmental protection (Papyrakis, 2013). Contrarily, stronger and more coherent civil institutions are expected to improve the voluntary adherence to the best environmental practices and increase compliance with environmental regulations (El Anshasy and Katsaiti, 2014).

Table 2: Variables and sources

Variable	Definition	Source
per capita Real GDP	per capita Real GDP (2005 $US ppp)	WDI on-line, World Bank

Manufacturing	the ratio of manufacturing value added (ISIC D) to GDP, both measured in current prices	the UN national accounts main aggregates database
Energy Intensity	Energy use (kg of oil equivalent) per $1 of GDP (constant 2005 PPP)	International Energy agency, 2012
Civil Liberties	An index originally ranging from 1 (best) to 7 (worst) but is rescaled to range from zero (least respect for civil rights) to 6 (full respect). It captures the freedoms of expression and belief, associational and organizational rights, rule of law.	*Freedom in the World* survey (Freedom House), 2012
Bureaucracy Quality	An index that ranges from zero (worst) to 4 (best) and captures the institutional strength and quality of the bureaucracy. High points are given to countries that govern without drastic changes in policy or interruptions in government services.	ICRG- The PRS Group
Low & Order	An index that ranges from zero (weakest) to 6 (strongest). The Law sub-component assesses the strength and impartiality of the legal system; while the Order reflects popular observance of the law.	ICRG- The PRS Group
Judiciary Independence	An index that ranges from zero (least independent) to two (most independent) and it indicates the extent to which the judiciary is independent of control from another branch of the government or the military.	Cingranelli-Richards (2008) –the CIRI Human Rights Database
per capita CO2	Metric tons of CO2 per person	International Energy agency, 2012

Civil liberties and free association rights are expected to raise environmental awareness and increase the demand for environmental protection as a public good through forming environmental societies. Law and order and judiciary independence are important to environmental regulations' enforcement (El Anshasy and Katsaiti, 2014). Bureaucracy quality, on the other hand, is an indicator of the strength of governance and the quality of public goods provision. Therefore, this indicator is expected to directly measure of the quality of the government's environmental protection function.

The choice of the appropriate econometric techniques is guided by a number of considerations. First, panel data introduces great deal of unobserved heterogeneity. Second, the conventional assumption of cross-sectional independence is inappropriate because the six GCC countries share similar economic structures and historical and cultural heritage that makes them more vulnerable to global common shocks and spillover effects. The failure to account for such cross-sectional dependence can lead to inconsistent and incorrect inferences. Third, some unobserved nonstationary common factors may affect some or all variables in the panel and therefore it may be more appropriate to consider the possibility of cointegration not only within each group but also across groups.

Our empirical investigation proceeds by first testing for cross-section dependence, unit roots, and cointegration. After establishing cointegartion, we estimate the long-run cointegrating relationships and long-run elasticities, and lastly estimate the heterogeneous short-run transitional dynamics. The following subsections describe each of these steps in further detail.

Cross-section dependence and unit roots

We use the test developed by Pesaran (2004) to check for cross-sectional dependence (CD). The test's null hypothesis is *the absence* of cross-sectional dependence in the panel data. The CD test is based on a simple average of all pair-wise correlation coefficients of the OLS residuals obtained from standard augmented Dickey-Fuller regressions for each group in the panel. So, in our panel we have 6 countries, and hence have 6x5 =30 possible correlations for each variable. Pesaran's CD test statistic is computed as follows:

$$CD_x = \sqrt{\frac{2T}{N\,(N-1)}} \sum_{i=1}^{n-1} . \sum_{j=i+1}^{n} \hat{\rho}_{ij} \qquad (1)$$

Where $\hat{\rho}_{ij}$ is the pair-wise correlation coefficient for the specific variable *x* between country *i* and *j*. The detection of cross-sectional correlation provides support for the importance of using techniques that account for such cross-country correlations.

We employ four panel unit root tests, all of which consider country heterogeneity. Maddala and Wu (1999) (MW), Im, Pesaran and Shin's (2003) (IPS) and Hadri's (2000) (HAD) tests assume cross-sectional *independence*. Unlike the first two tests in which the null hypothesis is panel unit root, HAD's null hypothesis is that all panels are stationary. So, the rejection of the null provides stronger evidence in favor of the existence of unit roots. Despite the fact that HAD, as in MW and IPS above, does not address cross-sectional dependence, it mitigates the problem by demeaning all series in the panel.

We then relax the assumption of cross-sectional independence and check the robustness of the unit root results. We apply Pesaran's (2007) Cross-sectional augmented IPS (CIPS) test which is based on the following Cross-section Augmented Dickey-Fuller (CADF) regression.

$$\Delta x_{i,t} = \delta_i + \alpha_i \, x_{i,t-1} + \beta_i \, \bar{x}_{i,t} + \gamma_i \, \Delta\bar{x}_{i,t} + \varepsilon_{i,t} \qquad (2)$$

Here x is a panel variable; Pesaran (2007) suggests that the mean $\bar{x}_t$, given by $\bar{x}_{i,t} = \frac{1}{N}\sum_{i=1}^{N} x_{i,t}$, can capture information on the common factors. The CIPS statistic is a simple average of the t-statistics on the α_i coefficients. That is: $CIPS = \frac{1}{N}\sum_{i=1}^{N} t_{\alpha_i}$.

Panel cointegration and the cointegrating relations

Unit root tests reveal that all variables are I(1); hence we proceed to determine whether the panel's variables are cointegrated. We use four bootstrap tests developed by Westerlund (2007). Unlike most available residual-based panel cointegration tests, these tests are based on estimating a standard Error Correction Model in which both the long-run and short-run coefficients are allowed to vary across panel groups. Westerlund (2007) tests examine the absence of cointegration by determining whether an error correction process exists for individual panel members or jointly for the panel as a whole. Two of these tests are mean-group tests which allow error correction coefficients to vary across groups. The remaining two are pooled panel tests which assume homogeneous error correction coefficients for all groups. These tests have the advantage of accommodating correlation both within and between the individual cross-sectional units while allowing for a large degree of heterogeneity.

After establishing cointegration, the Mean-Group Common Correlated Effects (CCEMG) estimator suggested by Pesaran (2006) is used to obtain the long-run elasticities for each country. This estimator corrects for cross-dependence while allowing for full heterogeneity in the estimated coefficients. It also provides a panel-level estimates calculated as the simple mean of individual groups' estimates. We estimate the following model.

$$CO2_{i,t} = \alpha_i + \delta_i X_{i,t} + \mu_1 \overline{CO}2_t + \mu_2 \bar{X}_t + u_{i,t} \tag{3}$$

Where $CO2$ is per capita CO2 emissions, X is a matrix of our four explanatory variables. The model in Equation 3 is augmented with the cross-section panel averages of the dependent and independent variables, $\overline{CO}2$ and $\bar{X}$, as proxies for the unobserved factors. The CCEMG method has many advantages. It offers consistent estimates, accommodates time-variant unobservable variables with heterogeneous impacts across panel members, and is the most efficient in the presence of common factors (Kapetanios and Pesaran, 2007). In addition, this technique is robust in the presence of a limited number of 'strong' unobserved common factors and an infinite number of 'weak' factors. These unobserved factors may contain unit roots and (or) structural breaks in their mean (Kapetanios et al., 2011). Coakley et al. (2006) find that the CCEMG is also robust to the non-stationarity of the panel variables.

Pooled Mean-Group estimations and the short run dynamics

We finally use the Pooled Mean-Group estimator (PMG) (Pesaran and Smith, 1995, and Pesaran et al., 1999) to mainly estimate the pooled long-run elasticities as a robustness check and the short-run error correction coefficients that measure the speed of adjustment to equilibrium. This estimator allows for heterogeneity in the short-run dynamics, but assumes a common long-run relationship across panel groups. The PMG is consistent and efficient even in the presence of endogenous and non-stationary regressors (Pesaran et al., 1999).

We estimate the following Error Correction Model:

$$\begin{aligned} \Delta CO2_{it} &= \Phi_i S_{i,t-1} + \sum_{s=1}^{n} \lambda_{is}^{'} \Delta CO2_{i,t-s} + \sum_{j=1}^{m} \delta_{ij}^{'} \Delta X_{i,t-j} + \mu_i + \varepsilon_{it} \\ S_{i,t-1} &= CO2_{i,t-1} - \alpha - \theta^{'} X_{i,t-1} \end{aligned} \tag{4}$$

Where, $S_{i,t-1}$ is the deviation from long run equilibrium at any period for group *i*, and Φ_i is the error-correction (speed of adjustment) coefficient. The vector $\theta^{'}$ captures the homogeneous long-run coefficients of interest; these coefficients represent CO2's long-run elasticity with respect to each variable in $X_{i,t-1}$ where the latter is a kx1 vector of variables (in logarithms) that is expected to affect emissions growth both in the short run and in the long run. The short run responses of the *X* variables are captured by the vector $\delta^{'}$; μ_i is group-specific effects and ε_{it} is the error term.

4. Results and Policy Discussion

In this section we first lay out the results from cross-dependence CD, unit roots, and cointegration testing then turn to long-run estimations and short-run adjustment dynamics. Table 3 presents the results from Pesaran's (2004) CD test. Except for real GDP per capita, the test statistics reject the null hypothesis of cross-section independence. When real GDP is tested for CD, again, the test is able to reject the null of independence. Therefore, we conclude that cross-sectional dependence exists in the panel. This implies that, indeed, the GCC countries are subject to common global shocks and regional spillover effects.

The results from the four unit root tests are presented in Table 4; MW and IPS tests indicate that the null of unit roots cannot be rejected except for three variables in levels: energy intensity, law and order, and per capita CO2. However, after correcting for cross-section dependence and using the HAD stationarity test, we conclude that all panel variables have unit roots; the null hypothesis of stationarity is strongly rejected in the HAD test and the CIPS test statistics cannot reject the null of unit roots.

All tests, however, confirm that variables are stationary in first differences, indicating that all variables are following an I(1) process. Although HAD test rejects per capita GDP's stationarity in first difference, all the other three tests suggest stationarity for that variable. It is also worth noting that the results of these tests after adding a trend (not shown) did not change the conclusion.

Table 3: Pesaran (2004) CD test- average correlation coefficients

Variable	CD-test	p-value	corr	abs(corr)
CO2 per capita	15.69	0.000	0.641	0.641

Energy intensity	9.330	0.000	0.381	0.709
Real GDP per capita	0.201	0.844	0.008	0.468
Real GDP 2005 $US	17.85	0.000	0.729	0.729
Manufacturing % GDP	18.43	0.000	0.752	0.752
Civil liberties	2.79	0.005	0.114	0.253
Bureaucracy quality	-2.84	0.005	-0.141	0.480
Low & Order	16.83	0.000	0.836	0.836
Judiciary independence	2.01	0.045	0.095	0.199

Note: all variables are in logs. Under the null hypothesis of cross-section independence CD ~ N(0,1)

Table 4: Panel unit root tests

Variable	MW		IPS		HAD		CIPS	
	Level	Difference	level	Difference	level	Difference	level	Difference
Real GDP pc	14.4	33.95***	-0.75	-4.76***	9.22***	3.98***	-0.94	-1.40*
Manufacturing	14.0	53.98***	-0.52	-8.94***	9.41***	-0.174	-0.812	-1.63**
Energy Intensity	40.7***	59.82***	-3.31***	-5.59***	11.11***	-0.029	-1.22	-1.53*
Civil Liberties	8.6	101.7***	-0.54	-7.17***	4.32***	-0.393	0.847	-3.20***
Bureaucracy	11.68	38.02***	-0.58	-3.81***	6.69***	-0.866	2.563	-3.19***
Low & Order	31.98***	37.45***	-2.04**	-3.82***	4.15***	-1.505	1.958	-4.72***
Judiciary Ind.	3.977	50.61***	0.35	-5.81***	2.68***	1.158	3.499	-4.59***
CO2 per capita	45.5***	80.03***	-1.44*	-7.66***	12.94***	-0.273	0.63	-1.73**

Note: all level tests do not include trend. Results of levels with trend are not shown and they do not change the conclusion of the results shown here. All tests include three lags. Cross-sectional means are removed in the IPS and Hadri tests. The null hypothesis for MW, IPS, and the CIPS tests is that all panels contain unit roots. On the contrary, Hadri test's null is that all panels are stationary. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively. Except bureaucracy quality and law and order, all variables are in natural logarithm. MW= Maddala and Wu (1999) test; IPS= Im-Pesaran-Shin (2003) test, HAD= Hadri (2000) test; CIPS= Pesaran's (2007) Cross-sectional Augmented IPS test.

Now we turn to Westerlund (2007) cointegration tests. Table 5 presents the results from testing five cointegrating vectors (CI1 to CI5) which vary in terms of the institutional variable included. The first vector does not include any measure of institutional qualities; all four tests are able to reject the null of *no* cointegration, indicating that all four variables are cointegrated. When various institutional qualities are entered in the subsequent vectors, the tests were again able to reject the null hypothesis of no cointegration; all panel (pooled) test statistics are significant in all tested vectors. On the other hand, at least one mean-group test reject the null in all five vectors. So, taken altogether, this evidence is deemed satisfactory to establish cointegration between per capita CO2, energy intensity, per capita real GDP, manufacturing share, and each of the institutional qualities: civil liberties, judiciary independence, bureaucracy quality, and law and order.

Table 5: Westerlund (2007) ECM Panel Cointegration Tests

Statistic	CI1	CI2	CI3	CI4	CI5
Gt	**-2.504**	-2.112	-2.922	-2.417	**-3.337**
	[0.10]*	[0.46]	[0.22]	[0.43]	**[0.02]****
Ga	**-14.231****	**-11.166**	**-12.892**	**-16.881**	**-12.925**
	[0.03]	**[0.10]***	**[0.09]***	**[0.01]*****	**[0.02]****
Pt	**-6.272**	**-6.564**	**-8.993**	**-6.262**	**-8.567**
	[0.07]*	**[0.09]***	**[0.01]*****	**[0.06]**	**[0.04]****
Pa	**-15.987**	**-14.461**	**-15.165**	**-14.739**	**-15.552**
	[0.02]**	**[0.01]*****	**[0.03]****	**[0.00]*****	**[0.03]****

Note: Robust *P*-values in square brackets. All estimations include trend and one lag. Estimations with no trend do not suggest different conclusions and are suppressed for space considerations. All variables are in natural logarithms. Critical values bootstrapped under the null of no cointegration. Bold p-values are those significant at least at the 10% level. **CI1=** CO2 Per capita, Real GDP pc, Manufacturing, Energy Intensity, Fossil Fuel (1972-2010); **CI2=** variables in CI1 and Civil Institutions (1972-2010); **CI3**= variables in CI1 and Judiciary Independence (1981-2010); **CI4**= variables in CI1 and Bureaucracy quality (1984-2010); **CI5=** variables in CI1 and Law and Order (1984-2010).

Long- run elasticities

Next, we present the results from estimating the long-run run elasticities, assuming full heterogeneity and cross-dependence. All subsequent estimations differ in terms of the entered institutional quality, leading to differences in the panel's time-dimension. It is therefore worth noting that the estimated coefficients are not readily comparable across estimations. This exercise, however, serves as a valid robustness check of our core results which remain highly robust across samples.

Table 6 shows the CCEMG results from the estimation of our five cointegrating vectors, where per capita CO2 is the dependent (normalized) variable. We show the estimated long-run elasticities from estimating Equation 3 for each GCC country in addition to the mean-group results.

In all five cointegrated relations, the highly positive and significant coefficient of energy intensity indicates that higher emissions are associated with higher energy intensity in the long-run, and vice versa, in *all* six countries with no exception. In light of the mean-group elasticity estimates, it is worth highlighting two important findings. First, as anticipated, the longer the time-dimension of the panel (in CI1 and CI2) the greater the long-run responsiveness of emissions to changes in energy intensity; the coefficient ranges between 0.84-0.81. Second, the mean-group elasticity ranges from 0.84 to 0.59; taking the upper bound, a reduction in energy use per unit of GDP by 10% would result in about 8% reduction in per capita CO2 emissions.

Table 6: Estimating the long-run elasticities (Pesaran (2006) Common Correlated Effects CCE)

Dependent variable: CO2 Per capita	**UAE**	**BHR**	**KWT**	**OMN**	**QAT**	**SAU**	**CCE-Mean Group**
CI 1 (1971-2010) * **							
Real GDP pc	**0.95*** (0.038)**	**0.72*** (0.105)**	**0.84*** (0.041)**	**1.06*** (0.222)**	**0.79*** (0.076)**	**1.32*** (0.198)**	**0.93*** (0.097)**
Manufacturing (% GDP)	0.003 (0.015)	0.08 (0.055)	-0.02 (0.023)	0.004 (0.090)	-0.06 (0.062)	0.15 (0.165)	0.02 (0.037)
Energy intensity	**0.91*** (0.031)**	**0.52*** (0.103)**	**0.97*** (0.034)**	**0.71*** (0.077)**	**0.78*** (0.053)**	**0.88*** (0.078)**	**0.81*** (0.074)**
CI 2 (1971-2010) * **							
Real GDP pc	**0.97*** (0.041)**	**0.64*** (0.092)**	**0.86*** (0.024)**	**1.08*** (0.206)**	**0.80*** (0.076)**	**1.44*** (0.209)**	**0.93*** (0.125)**
Manufacturing (% GDP)	0.002 (0.015)	**0.13*** (0.044)**	**-0.04*** (0.013)**	0.01 (0.096)	-0.09 (0.061)	**0.29* (0.178)**	0.03 (0.061)
Energy intensity	**0.93*** (0.033)**	**0.47*** (0.083)**	**1.04*** (0.023)**	**0.74*** (0.071)**	**0.77*** (0.053)**	**0.93*** (0.081)**	**0.84*** (0.095)**
Civil institutions	-0.04 (0.027)	**0.15*** (0.053)**	**-0.14*** (0.019)**	**0.26** (0.127)**	0.04 (0.062)	**0.09* (0.050)**	0.06 (0.065)
CI 3 (1981-2010) * **							
Real GDP pc	**0.97*** (0.067)**	**0.63*** (0.162)**	**0.83*** (0.051)**	**0.81** (0.334)**	**0.58*** (0.116)**	**1.21** (0.297)**	**0.83*** (0.102)**
Manufacturing (% GDP)	**-0.08* (0.043)**	**0.27*** (0.066)**	-0.02 (0.025)	0.14 (0.110)	0.089 (0.086)	**0.30* (0.166)**	0.11 (0.067)
Energy intensity	**0.87*** (0.056)**	**0.68*** (0.134)**	**1.00*** (0.029)**	**0.73** (0.197)**	**0.58*** (0.074)**	**0.56*** (0.131)**	**0.73*** (0.076)**
Judiciary Independence	**-0.04*** (0.012)**	**-0.07*** (0.020)**	**-0.02* (0.014)**	**-0.07** (0.037)**	-0.05 (0.049)	-0.02 (0.025)	**-0.04*** (0.012)**
CI 4 (1984-2010) * **							
Real GDP pc	**0.87*** (0.068)**	**0.64*** (0.191)**	**0.73*** (0.093)**	**1.07* (0.586)**	**0.43** (0.219)**	**0.84*** (0.284)**	**0.77*** (0.106)**
Manufacturing (% GDP)	**-0.13* (0.076)**	**0.28*** (0.088)**	-0.01 (0.030)	0.05 (0.119)	0.06 (0.089)	**0.30** (0.148)**	0.09 (0.079)
Energy intensity	**0.87*** (0.074)**	**0.26* (0.150)**	**0.85*** (0.037)**	**0.82*** (0.211)**	**0.45*** (0.158)**	**0.30** (0.153)**	**0.59*** (0.135)**
Bureaucracy qualities	0.003 (0.067)	0.11 (0.087)	**0.19*** (0.075)**	**0.29* (0.176)**	0.04 (0.112)	0.05 (0.118)	**0.11** (0.052)**
CI 5 (1984-2010) * **							
Real GDP pc	**0.92*** (0.059)**	**0.87*** (0.143)**	**0.97*** (0.031)**	0.73 (0.538)	**0.52*** (0.149)**	**0.80*** (0.299)**	**0.82*** (0.072)**
Manufacturing (% GDP)	**-0.12* (0.062)**	**0.29*** (0.078)**	-0.01 (0.019)	**0.28** (0.116)**	0.10 (0.095)	**0.28** (0.129)**	0.15 (0.091)
Energy intensity	**0.88*** (0.083)**	**0.34** (0.171)**	**0.97*** (0.022)**	**0.67*** (0.199)**	**0.51*** (0.092)**	**0.25* (0.164)**	**0.60*** (0.128)**
Low & order	-0.06 (0.116)	-0.06 (0.123)	**-0.28*** (0.052)**	**0.52* (0.294)**	0.16 (0.102)	0.17 (0.142)	0.04 (0.146)

Note: *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively. Constants are suppressed to conserve space. Robust standard errors are reported in parentheses. All regressions include a constant, trend, and common correlated effects terms proposed by Pesaran (2006). UAE= United Arab Emirates; BHR= Bahrain; KWT= Kuwait; OMN= Oman; QAT= Qatar; SAU= Saudi; All variables are in natural logarithms.

Put differently, *ceteris paribus*, a long-run goal of a 10% reduction in the region's emissions would require lowering intensity by roughly 12%, on average. From a public policy perspective, this result clearly shows that energy efficiency and conservation *alone* may not be viable policy options to significantly cutting emissions (e.g., by half) in the next few decades. Therefore, investing in CS technologies and a strong commitment to renewable energy seem essential ingredients to any sustainable development strategy for the region.

Table 6 also shows the CCE estimates per country. The elasticity of emissions to energy intensity is relatively high in Kuwait, UAE and Oman. Confirming the findings of previous studies, energy efficiency and conservation policies have better environmental prospects in these three countries, in particular. The result for Kuwait and Oman is also in line with the large electricity transmission and distribution inefficiencies discussed earlier. In Qatar and Saudi Arabia, when the oil shocks era of the seventies is excluded, the long-run elasticity show very significant reduction, possibly indicating an effort to improve energy efficiency in more recent years. Bahrain shows a moderate, yet significantly positive, elasticity.

The second set of results shed some light on the environmental impact of the region's high policy emphasis on diversification and expanding the manufacturing sector. As noted from Table 6, the mean-group elasticity of manufacturing is positive but not significant in all five cointegrated relations, lending no support to the notion that manufacturing has a negative effect on environmental performance in the long-run. Looking at the country-level, however, shows that such evidence can only be established for Bahrain and Saudi Arabia; the coefficient of manufacturing is robustly positive and significant. A 10% increase in the share of manufacturing in any of these countries would increase per capita CO2 levels by 2% to 3%. This calls for establishing stringent environmental regulations for manufacturing in these two countries. In all other four countries, the elasticity with respect to manufacturing is insignificant or rather negative (as in the case of UAE), possibly indicating that the growth in manufacturing was insignificant to hurt the environment in the past few decades.

The results for institutions are rather mixed. It should be however noted that different institutional indexes represent various institutional qualities that are not expected to affect the environment in the same manner or at the same rate. The mean-group results suggest that the only institutional factor that seems to be associated with reductions in emissions in the long-run is Judiciary independence; the coefficient is significantly negative. It is also the only institutional quality that is robustly consistent with lower CO2 emissions in *all* GCC countries. The elasticity is significantly negative for Bahrain, Kuwait, Oman, and UAE. An independent judiciary system ensures stronger and equal law enforcement among all economic agents. In addition, it guards against any state enterprise-bias where the public sector is playing a significant role in the economy such as in the GCC region.

Table 7: Long-run elasticities (Pesaran et al. (1995, 1999) Pooled Mean-Group PMG)

Dependent variable: $CO2$ Per capita $_t$	(1) 1971-2010	(2) 1971-2010	(3) 1981-2010	(4) 1984-2010	(5) 1984-2010
Real GDP pc	**0.979*** (0.020)**	**0.966*** (0.022)**	**0.951*** (0.027)**	**1.037*** (0.039)**	**1.048*** (0.036)**
Manufacturing (% GDP)	**0.03*** (0.010)**	**0.03*** (0.010)**	-0.02 (0.016)	-0.02 (0.022)	-0.01 (0.015)
Energy Intensity	**0.94*** (0.016)**	**0.94*** (0.017)**	**0.89*** (0.024)**	**1.08*** (0.055)**	**1.00*** (0.041)**
Civil Liberties		0.03 (0.024)			
Judiciary Independence			**-0.02*** (0.005)**		
Bureaucracy Quality				**-0.06** (0.028)**	
Law and Order					**-0.13*** (0.025)**
No. of Observations	**228**	**228**	**168**	**150**	**150**
Log likelihood	**387*** **	**389*** **	**344*** **	**326*** **	**328*** **

Note: all models include a dummy variable to account for the observed time breaks in the data as follows: Bahrain 1973-1977; Kuwait 1991-1992; Oman 1991; and Qatar 1997-1998. Standard errors are reported in parentheses *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are in natural logarithms. Long-run pooled results not reported.

Contrarily, better bureaucracy quality seems to be associated with higher (not lower) emissions levels. The sign is positive for *all* GCC countries, but only significant in Kuwait and Oman. One possible explanation is that the quality of government services would capture the quality of the environmental protection function of the government but not the magnitude of this function or the effectiveness of environmental policies. On the other hand, the quality of the provision of government services is usually associated with the adoption of more advanced technologies and higher use of energy. The coefficients of law and order, and civil liberties show the expected negative sign, but are insignificant. A final interesting remark is that the only country in the GCC region where CO2 emissions seem robustly responsive to strengthening institutions and improvements in judiciary independence, law and order, and civil liberties is Kuwait. It is interesting to note that Kuwait has relatively the most representative political system in the region which may explain the positive impact of institutional improvements.

Lastly, as expected, for less developed nations such as the GCC countries, higher economic activity increases CO2 emissions in the long-run. The elasticity is high and is close to one (or exceeds one in the cases of Oman and Saudi Arabia) in all six countries, but is relatively smaller in Bahrain.

We now relax the assumption of heterogeneous long-run elasticity across the region. Table 7 presents the PMG estimates of the pooled long-run elasticity for the six countries, assuming homogenous long-run responses to energy intensity. Note that the PMG long-run estimates are comparable to the corresponding CCE mean-group estimates in Table 6, so they serve as robustness checks. In sum, all our core results remain robust. Energy intensity still shows positive and highly significant unit elasticity. It should be, however, mentioned that elasticity estimates for all variables across all estimations are higher than the CCE mean-group estimates. The other difference is related to institutions. When the long-run estimates are pooled, law and order, and civil liberties show a negative sign. Meanwhile, judiciary independence elasticity remains robustly significant and negative.

Short-run adjustment dynamics

The short-run dynamics are obtained from estimating the error correction model in Equation 4, using PMG and allowing heterogeneity in the short-run transitional dynamics. The upper panel of Table 8 presents the short-run elasticities for the five cointegrating relations (only showing the mean-group estimates). The lower panel reports both mean-group and country-level adjustment coefficients.

All adjustment coefficients in the lower panel appear significant and have the correct (negative) sign, confirming that all five relations are cointegrated for all six countries. It is interesting to see that the UAE and Kuwait, not only are more responsive to lowering energy intensity, but also have the highest speed of adjustment. That is: a shock to energy intensity which results in a deviation of CO2 emissions from equilibrium would be corrected faster than in other GCC countries. From a public policy perspective, policies which aim to lower energy intensity would be more effective in these countries since equilibrium, at lower levels of CO2 emissions, would be restored relatively faster.

Table 8: Short-run dynamics (Pesaran et al. (1995, 1999) Pooled Mean-Group PMG)

Dependent variable: Δ CO2 Per capita $_{t}$	(1) 1971-2010	(2) 1971-2010	(3) 1981-2010	(4) 1984-2010	(5) 1984-2010
Δ Real GDP pc$_{t-1}$	-0.17 (0.147)	**-0.22*** **(0.121)**	-0.07 (0.137)	-0.02 (0.170)	-0.01 (0.140)
Δ Manufacturing (% GDP) $_{t-1}$	**0.02***** **(0.003)**	**0.03***** **(0.003)**	**0.03***** **(0.06)**	**0.02***** **(0.007)**	**0.03***** **(0.005)**
Δ Energy intensity $_{t-1}$	-0.08 (0.140)	-0.14 (0.108)	-0.05 (0.092)	-0.001 (0.105)	-0.01 (0.062)
Δ Civil institutions $_{t-1}$		0.01 (0.015)			
Δ Judiciary Independence $_{t-1}$			0.006 (0.011)		
Δ Bureaucracy qualities $_{t-1}$				-0.11 (0.091)	
Δ Low & order $_{t-1}$					0.009 (0.069)
Δ CO2 Per capita $_{t-1}$	**0.32*** **(0.197)**	**0.38**** **(0.154)**	**0.19***** **(0.132)**	0.08 (0.107)	0.11 (0.090)

Speed of Adjustment (EC) coefficients					
Mean Group	**-0.66*** (0.122)**	**-0.67*** (0.119)**	**-0.59*** (0.111)**	**-0.43*** (0.124)**	**-0.48*** (0.129)**
United Arab Emirates	**-1.00*** (0.043)**	**-1.00*** (0.043)**	**-0.98*** (0.044)**	**-0.98*** (0.044)**	**-0. 81*** (0.061)**
Bahrain	**-0.27*** (0.061)**	**-0.28*** (0.061)**	**-0.26*** (0.063)**	**-0.19*** (0.066)**	**-0.20*** (0.064)**
Kuwait	**-0.85*** (0.048)**	**-0.84*** (0.047)**	**-0.85*** (0.038)**	**-0.81*** (0.031)**	**-0.93*** (0.032)**
Oman	**-0.47*** (0.098)**	**-0.48*** (0.099)**	**-0.47*** (0.103)**	**-0.32*** (0.107)**	**-0.43*** (0.127)**
Qatar	**-0.90*** (0.057)**	**-0.91** (0.059)**	**-0.52*** (0.121)**	**-0.27*** (0.105)**	**-0.33*** (0.119)**
Saudi Arabia	**-0.46*** (0.131)**	**-0.48*** (0.131)**	**-0.44*** (0.108)**	**-0.17*** (0.059)**	**-0.17** (0.077)**
No. of Observations	**228**	**228**	**168**	**150**	**150**
Log likelihood	**387*** **	**389*** **	**344*** **	**326*** **	**328*** **

Note: all models include a dummy variable to account for the observed time breaks in the data as follows: Bahrain 1973-1977; Kuwait 1991-1992; Oman 1991; and Qatar 1997-1998. Standard errors are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are in natural logarithms. Long-run pooled results not reported.

On the other hand, Saudi and Qatar witnessed a notable drop in the size of the adjustment coefficient when the period of high oil prices is excluded, indicating much slower adjustment to equilibrium. In Saudi Arabia, for instance, when only the period 1984-2010 is considered, the error correction speed significantly drops to 0.17 [Z-test on the difference=2.04, p-value = 0.0414]. This indicates that the time it takes to restore equilibrium considerably increased to roughly 7.5 years.[4] The policy implication is that emissions in Saudi Arabia would be the slowest to settle at lower levels after the adoption of energy efficiency policies.

Energy intensity appears insignificant in the short-run. In fact, the sign of its coefficient is negative in all estimations. It should be, however, emphasized that conservation and energy efficiency policies are likely to impact energy intensity in the long-run. That is, the short-run variations in energy intensity are usually driven by the business cycle (i.e., short-run changes in real GDP). For example, during the 2008-2009 worldwide recessions, the GCC countries did not witness a significant reduction in energy use despite slowing down economies. Lastly, despite the insignificance of manufacturing in the long-run, the expansion of manufacturing seems to have transitory negative effect on CO_2 emissions in all six countries.

[4] Half the distance to equilibrium will be cut in 3.7 periods [ln(0.5)/ln(1+adjustment coefficient)= ln(0.5)/ln(1+(-0.17))=3.7]

5. Conclusion

This study has argued that there is a long-run equilibrium relationship between environmental performance, measured by per capita CO2 emissions, and energy intensity. Lowering energy intensity by improving energy efficiency and conservation would reduce emissions in the long-run in all six member countries. These implications are particularly profound for Kuwait, Oman and UAE. We make a strong case for the importance of gradually removing energy subsidies. The deregulation of prices is expected to create incentives, especially in the industrial sector, to invest in more energy efficient methods and technologies.

Despite their great potential, the estimated long-run elasticities show that energy efficiency and conservation *alone* may not be viable policy options to significantly cutting emissions in the next few decades. Investing in Carbon Sequestration (CS) technologies and a strong commitment to renewable energy seem essential ingredients to any sustainable energy and environmental strategy for the region. Evidence on a negative long-run effect of manufacturing on environmental performance is only established for the cases of Bahrain and Saudi Arabia, indicating the need for more stringent environmental industrial policy in these two countries. We find judiciary independence to be an essential institutional quality for the successful implementation of any sustainable long-run environmental or energy policy.

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Appendix

Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Per capita CO2	240	19.48396	10.78845	0.33	47.83
Energy intensity	240	0.224647	0.133373	0.011576	0.821834
Manufacturing to GDP	246	6.852741	3.881412	0.308987	18.55159
Per capita GDP (USD 2005)	240	43040.22	32499.62	7868.132	189375.9
Civil liberties	240	5.3625	0.85193	3	7
Judiciary independence	180	1.055556	0.546418	0	2
Bureaucracy quality	162	2.17749	0.5168	0.583333	3
Law and order	162	4.401132	0.921973	1.75	6

Note: for variable definitions and measurement see Table 2