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Industrial Energy Prices and Export Competitiveness: Evidence from India

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Abstract

Using a panel for the period 1998-2009, we estimate the response of Indian exports for 11 energy intensive sectors to sectoral level energy price asymmetry. We apply dynamic gravity model of trade proposed by Olivero and Yotov (2012). We observe absence of the *contemporaneous effect* of energy price differential on Indian exports, but *presence of persistence effects*. It is found that a 10 percent increase in relative energy prices negatively affects Indian sectoral exports by about 1 percent ranging from 0.9 percent for chemicals to 1.4 percent for non-ferrous metals, revealing a larger impact for energy intensive sectors. These small effects imply that the concerns of carbon leakage are largely overplayed.

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1. Introduction

A unilateral carbon policy, like the Kyoto Protocol, results in regulatory difference between the trading partners and the abatement efforts in one country are expected to be offset by increased pollution levels in another country (Antweiler et al., 2001; Frankel, 2005; Copeland and Taylor, 2004; Levinson and Taylor, 2008). However, the empirical evidence involve only a few studies and are not decisively conclusive. Reasons for inconclusivity could be found in the fact that most of the unilateral climate policies put into practices are in their nascent stage and there is a lack of observed data. Moreover, it is difficult to compare the stringency of existing unilateral climate policies in a meaningful way (Sato and Dechezleprêtre, 2015).[1]

A possible way to overcome these limitations is using energy price differential between trading partners as a proxy for carbon mitigation policy and thereby evaluating whether changes in energy price differences between trading partners affect trade flows. Contrary to the stringency of climate policies, energy prices have the advantage of being comparable across countries, sectors and time, and are available for a large set of countries and a long time period (Sato and Dechezleprêtre, 2015). We analyse the impact of sectoral energy price differential on the Indian exports to its trading Kyoto and non-Kyoto countries.[2]

Empirical literature on carbon leakage can be classified in two categories: ex-ante and ex-post. A larger literature belongs to the former category and uses computable general equilibrium (CGE) modelling to estimate the effects of the Kyoto Protocol (KP) on the extent of the leakage and competitiveness of trading partners.[3] Extent of the leakage in these studies varies from moderate 5 percent to as large as 130 percent. In the second category, the literature is very scant and employs econometric estimation techniques (e.g., World Bank (2008), Aichele and Felbermayr, 2013, 2015). Note that to segregate the effect of KP, these studies use Kyoto dummy employing country level data. Sato and Dechezleprêtre (2015) point out that the Kyoto dummy may be correlated to other macro-economic shocks that affect a country's trade, and it becomes difficult to disentangle KP effect on trade from other macro-economic effects.

Higher energy prices could possibly increase marginal cost of production for the producers. The resulting energy price differential relative to their trading partners might lead them to produce fewer energy intensive exports and relocate the energy intensive production to a country with low energy prices (Hanna, 2010). Therefore, an alternative way is to use energy price differential between trading partners as a proxy for environmental/carbon mitigation policy to evaluate whether changes in energy price differences between trading partners affect trade flows. In comparison to the stringency of climate policies, energy price differential has the advantage of being comparable across countries, sectors and time (Sato and Dechezleprêtre, 2015). Sato et al. (2015) suggest that higher energy prices are the consequence of 'enforced' regulations and are expected to reflect and capture actual environmental stringency faced by the firms. The authors observe high correlation between industrial energy prices and four alternative measures for environmental regulations - energy intensity, emission intensity, the

[1] Emission Trading Schemes across the world vis a vis the European Union Emissions Trading Scheme (EU ETS), Emission Trading schemes in the US, South Korea, Japan, Canada, Australia, China's pilot emissions trading scheme; the UK's Climate Change Levy, California's climate program, British Columbia's carbon tax scheme etc.

[2] Kyoto binding countries include those countries that have legally binding specific emissions reduction targets under the Kyoto Protocol agreement whereas Non Kyoto countries are the ones that are not legally bound to achieve such targets

[3] For example see, Felder and Rutherford, 1993; Bernstein et al., 1999; Burniaux and Martins, 2000; Babiker, 2005; Elliott et al., 2010;

2012 Environment Performance Index, and the two versions of the Industry Adjusted Emission Intensity (IAEI combustion and process and IAEI combustion) – establishing it as a good indicator for environmental regulation stringency.

Monjon and Quirion (2010) find the occurrences of carbon leakage not through relocations of Green House Gas intensive industries, but through the energy prices channel. Aldy and Pizer (2015) assess the impact of industrial electricity prices on sectoral production and consumption in the US. The authors estimate a series of regressions using a sample of industries at the 4-digit industry (SIC 1972) level of disaggregation. The study finds that an increase in energy prices in the US following the introduction of a 15$/ton carbon tax would induce a domestic production decline of between 3 and 4 percent among energy-intensive sectors and a roughly 1 percent increase in imports. With a few exceptions, the results indicate that consumers of energy-intensive goods do not respond to higher energy prices by consuming more imports. Instead, they economize the use of such high priced manufactured goods, either by using less of the energy intensive goods in the manufacture of their finished products or by substituting with other less energy-intensive goods. The study further finds that the responses to energy prices are bigger for industries with higher energy intensity. Gerlagh and Mathys (2011) evaluate the impact of marginal energy costs on the net exports using panel data comprising 14 high-income (OECD) countries over 28 years. The study uses a country specific energy abundance measure as a proxy for marginal energy costs. The authors view that energy abundance is a good proxy for energy prices since there is a high correlation between the two, and energy abundant countries have a high level of energy embodied in exports relative to imports and vice versa. This lends support to the carbon leakage phenomenon. The latest contribution to this literature is by Sato and Dechezleprêtre, (2015). They use data on trade and energy prices from 1996 to 2011 covering 42 countries and 62 sectors representing 60 percent of global merchandise trade during that period. The energy price data for the study is obtained from Sato et al. (2015) who construct an energy price index for a given sector in an year, by weighting fuel prices for four carriers (oil, gas, coal and electricity) by the consumption of each fuel type in the given sector thereby addressing the important issue of heterogeneous fuel mix observed across sectors and countries. The authors find evidence that widening of the energy price gap has a statistically significant but small effect on bilateral exports. A 10% increase in the energy price gap between two countries within a given sector translates on average into a 0.2% increase in imports. Overall, energy price differences across time explain less than 0.01% of the variation in trade flows.

Note that most of the studies focus on the developed part of the World, specifically the OECD countries. These studies find that energy price differentials between the trading partners impact the trade competitiveness but not in a drastic manner. Our paper deviate from this trend and focuses on India's exports to its top trading partners. It evaluates the impact of energy price differentials between India and its trading partners on India's industrial exports thereby commenting on the possibility of carbon leakage. Moreover, we attempt to address several econometric issues that have not been dealt in the literature on energy prices and trade. First, considering energy costs as a trade barriers and combing it with concepts of protection persistence effect of Olivero and Yotov (2012), we focus on the dynamic aspect and persistence impact of energy price differentials on the export levels. Second, endogeneity issue involved in the analysis of the impact of relative energy prices on the export flows. Third, heteroscedasticity issue that hampers the gravity estimates (Santos Silva and Tenreyro, 2006).

This paper focuses on India's industrial sectoral exports to its top trading partners from 1998 to 2009 and attempts to assess the impact of relative energy price on the exports using gravity model of international trade. We follow Olivero and Yotov (2012) to develop its conceptual framework. We employs dynamic gravity model to estimate the effects of energy price differentials on the export levels. The empirical application corrects for the econometric problems of heteroscedasticity, heterogeneity, and endogeneity. We use the Arellano-Bover (1995) / Blundell-Bond's (1998) system – GMM estimator that accounts for dynamic econometric concerns and allows for the estimation of the standard gravity variables, in addition to standard OLS and instrumental variable approach.

We find a negative relationship between the relative energy prices and Indian exports; the contemporaneous effect of relative energy price is insignificant. We observe a presence of persistence of differential energy price effect on Indian exports. It is found that about 10 percent increase in sectoral energy price in India relative to its trading partners reduces Indian exports by about 1 percent. This effect varies across sectors and years. The effect is small for the sectors like chemicals which are not so energy intensive, but the magnitude of the effect is slightly larger for the energy intensive sectors such as non-ferrous metal. The effect on average varies from 0.9 percent to 1.4 percent.

The small magnitude of the effect of the energy price differentials between India and its trading partners lends support to the argument that the trade and competitiveness are determined by other factors such as the quality of institutions in the trading countries, infrastructure, proximity to customers etc. (Demailly and Quirion, 2008). This is the reason that Indian exports have continuously been increasing even to the Kyoto ratifying countries. These results show that the concerns of carbon leakage have largely been overplayed and climate policy should not be dictated by these overplayed fears.

Rest of the paper is organized as follows. Conceptual and empirical framework is discussed in Section 2, and data is described in Section 3. Results of the gravity model are presented and discussed in Section 4. Some conclusions and policy implications are discussed in the concluding Section 5.

2. Conceptual Framework and Empirical Strategy

In the ex-post studies, it is a standard practice to estimate the reduced form *static* gravity equation to evaluate the effects of climate policy on bilateral trade (e.g., World Bank, 2008; Aichele and Felbermayr, 2015; Kumar and Prabhakar 2015). These studies are able to capture the *contemporaneous* effects of Kyoto Protocol on the trade volume, but ignore the *dynamic* effects of such kind of climate policies. In a recent paper, Baylis et al. (2014) show that as a result of introduction of unilateral climate policy, the firms may substitute out of carbon and substitute into the clean inputs since the elasticity of substitution is not zero between the dirty and clean inputs. Firms might be using less carbon per unit of output and the carbon leakage could be negative. It is also possible that the introduction of unilateral climate policy induces technological changes that increase substitutability between the carbon and clean inputs (Gerlagh and Kuik, 2007). Restrictions created by the unilateral climate policy may negatively affect the contemporaneous trade, but in the subsequent periods, due to diverging paths of relative factor endowments (i.e., ratio of carbon to clean inputs) it may have positive trade effect (Cunat and Mafferzzoli, 2007). That is, unilateral climate policy might have both, *contemporaneous* and *dynamic* effects. The dynamic gravity model of Olivero and Yotov (2012) captures these multi-period effects of a trade barrier policy.

In the Olivero and Yotov (2012) model, current trade flows are determined by the contemporaneous values, the lagged values of the trade, trade barriers and multilateral resistances. Intuitively, the model captures *trade persistence* and *protection persistence* effects in addition to the *contemporaneous* effects. Olivero and Yotov account for trade persistence by including lagged values of trade as regressor in the gravity model. Their model predicts that the current and lagged effects of trade barriers could be in opposite directions and the resulting persistence effect of trade protection could be either negative or positive. They control for the observable multilateral resistances by including time varying directional fixed effects.

The country size adjusted structural gravity equation of Olivero and Yotov (2012) for the Indian exports can be written as follows:

$$\check{x}_{ij,t} = \frac{1}{y_t^W}\left(\frac{t_{ij,t}}{\pi_{i,t}P_{j,t}}\right)^{1-\sigma}\left[\emptyset y_{j,t}^{1-\frac{1}{\alpha}} + \underbrace{\underbrace{(1-\delta)\left(\check{x}_{ij,t-1}y_{t-1}^{W}y_{j,t-1}\right)^{\frac{1}{\alpha}}}_{trade\ persistence\ effect} \times \underbrace{\left(\frac{t_{ij,t-1}}{\pi_{i,t-1}P_{j,t-1}}\right)^{\frac{\sigma-1}{\alpha}}}_{EP\ differential\ persistence\ Effect}}_{dynamic\ effect} y_{j,t}^{-\frac{1}{\alpha}}\right]^{\alpha} \quad (1)$$

where: $\check{x}_{ij,t}$ is the size adjusted volume of Indian exports to j country at time t ; y_t^W and y_{t-1}^W represent current and lagged world output ; y_{jt} and y_{jt-1} are the current and lagged values of importer country's GDP ; $\check{x}_{ij,t-1}$ is the lagged value of size adjusted exports from i to j ; $t_{ij,t}$ and $t_{ij,t-1}$ are the current and lagged values of trade barriers ; $\pi_{i,t}P_{j,t}\pi_{i,t-1}P_{j,t-1}$ are the current and lagged multilateral resistances for countries *i* and *j*, aggregating bilateral trade costs for the trading partners ; σ is the elasticity of substitution; Φ is the investment share of the real output; α is the output elasticity of the capital input.

This dynamic version of the gravity model nests the static version of the model. In equation (1), the first term represent the *contemporaneous effect* of trade barriers and the second term is related to dynamic effects of trade barriers. The lagged value of the size adjusted trade volume captures the *trade persistence effect* that accounts for the autocorrelation in bilateral trade flows. The lagged value of the trade barrier captures the dynamic effects of these barriers on the trade flows which are termed as trade *protection persistence effect* which in our case may be called *energy price (EP) differential persistence effect*. Variation in energy prices may induce firms' substitution between energy and non-energy inputs (Kumar and Managi, 2009) and between clean energy and fossil fuels (Kumar et al., 2015). Note that, as Sato et al. (2015) point out, the main reason for variation in energy price across the countries and sectors comes from the variation in energy taxation, and carbon prices affect trade competitiveness of a country by increasing effective cost of energy for production. Therefore, we assume that the variation in energy prices works as trade barrier.

Following the recent gravity literature, we estimate the following dynamic gravity equation in its multiplicative form:

$$\check{x}_{ij,t} = exp\left(\beta_{1p} \sum_{p=0}^{n} EP\ ratio_{ijs,t-p} + \beta_2 Fac_{ij,t} + \beta_3 Exp\ Reg_{i,t} + \beta_4 Imp\ Reg_{j,t} + \beta_5 Kyoto_{j,t} + \beta_{js} + \beta_{js,t}\right) \quad \sum_{p=1}^{n} \check{x}_{ij,t-p}^{1-\sigma} \exp(v_{ijs,t}) \qquad (2)$$

where: $\check{x}_{ij,t}$ is the size adjusted volume of Indian exports (*i*) to *j* country at time *t*; *EP ratio* is the ratio of sectoral energy prices between the trading partners *i* and *j* at time *t*. Similarly, *Fac* is the ratio of the capital to labour ratios between the trading partners *i* and *j* at time *t*, which measures the similarity in factor endowment between the trading partners; *Exp Reg* and *Imp Reg* represent the index of regulatory quality in the exporter and importer countries at time *t*; and v_{ijst} is a random disturbance assumed to be normal, and identically distributed with $E(v_{ijst}) = 0$; $Var(v_{ijst}) = \sigma^2 > 0$.

The estimation of conventional gravity model requires the incorporation of multilateral resistance measures (Anderson and van Wincoop, 2003). Trade cost can include transportation costs, policy barriers (tariffs and non-tariff barriers), information costs, contract enforcement costs, costs associated with the use of divergent currencies, legal and regulatory costs, and local distribution costs (wholesale and retail). To account for the variation of the multilateral resistance terms through time, Baier and Bergstrand (2009) do linear approximation to obtain unbiased and consistent reduced-form estimates. These costs could fall with better governance, good infrastructure, low tariffs, lower freight rates, common language and culture, and so forth. That is, trade facilitation is a process that reduces trade costs. Environmental regulations both in exporting and importing countries can also be incorporated in the gravity model (Harris et. al, 2002; van Beers and van den Bergh 1997).

The choice of the control variables is derived from the recent advances in the gravity literature. We have included the variable that accounts for whether a country has rectified the Kyoto Protocol to separate out the effect of energy price variation from the Kyoto rectification. The variable is defined as follows:

$Kyoto_{jt}$ = 1, if importer j has a binding emission cap and $t \geq$ year of ratification;
= 0, otherwise

In the control variables we also include whether the exporter and importers are members of any trading block. We control for country-pair sector fixed effects to account for time invariant country pair specific determinants such as distance, common language etc. as well sector specific characteristics. We have also controlled for directional country fixed effects to account for the unobservable multilateral resistances.

We estimate equation (2) for the industrial sectoral exports from India to its top trading partners. The common practice followed for estimation of gravity model is to estimate it using ordinary least square (OLS) method. Despite extensive use of such kind of practice, the OLS estimation of gravity model suffers from a number of econometric problems such as heteroscedasticity, endogeneity and heterogeneity and aggregation bias. Since we are using sectoral data and control for the sector specific characteristics using country-pair-sector fixed effect model, our estimates are supposed to be free from the problem of bias that arises due to heterogeneity and aggregation.

In our estimates, the source of endogeneity could be the lagged values of size adjusted exports flows and choice of energy variation variables. The endogeneity problem arising from the choice of energy prices can be addressed by using the instrumental variable approach and finding appropriate instrument for the concerned variable. Concern of endogeneity arising from the lagged values of trade could be addressed by using system GMM approach.

In the OLS estimation of gravity model the bias and inconsistency arising from heteroscedasticity is a serious concern. Santos Silva and Tenreyro (2006) suggest using Poisson Pseudo Maximum Likelihood (PPML) estimator to simultaneously control for heteroscedasticity and information contained in zero values of trade flows. In a recent paper Martinez-Zarzoso (2013) evaluates performance of different estimation techniques used for estimation of gravity model in the presence of heteroscedasticity and zero trade values. She compares the performance of Pseudo Poisson Maximum Likelihood (PPML), a Gamma Pseudo-Maximum-Likelihood (GPML), a Nonlinear Least Squares (NLS) estimator and a Feasible Generalized Least Squares (FGLS) estimator using Monte Carlo simulations and finds that though PPML is less affected by the heteroscedasticity, the performance of PPML in terms of bias and standard errors is no different than the other estimators. She recommends that the selection of estimator should be based on appropriate statistical tests.

For the estimation of the gravity model specified in equation (2), we follow Olivero and Yotov (2012). In our model the dependent variable has been adjusted for the size, and size adjustment essentially rescale the variance of the disturbances to decrease its variability, and thus reduces the problem of heteroscedasticity. We use the Ramsey regression equation specification error test (RESET), Sargan-Hansen, Durbin-Hausman and Arellano-Bond tests for the choice of appropriate functional form and estimator selection and instrument exogeneity.

The equation (2) is estimated using different versions of it. First, we use the static version of OLS representing the Anderson and van Wincoop gravity theory. Second, dynamic OLS, by including lags of export levels and energy price differential representing trade persistence effect and energy price variation persistence effect. To deal with endogeneity issues of energy price differential, we employ instrumental variables (IV) models. Lastly, we use Arellano-Bover (1995) /Blundell Bond's (1998) system-GMM estimator. This method estimates the model as a system of equations in levels and instruments with differenced instruments. Taking above issues into consideration, we resort to using fixed effects estimation of the gravity model.

3. Data

The objective of the paper is to find the impact of energy price differentials between India and its trading partners on the sectoral exports of India using dynamic gravity model. The choice of sectors and period of study are constrained by the availability of sectoral energy prices obtained from Sato et al. (2015). We study the period of 1998 to 2009. We need information on sectoral exports, sectoral energy prices, relative factor ratio, climate policy variables in addition to usual determinant such as distance, contiguity, common language etc. of a gravity model

Sectoral Exports

The analysis focuses on the industrial sectoral exports from India. The industrial goods follow ISIC revision 3 classification. The list of industrial goods is given in Appendix Table A1. Most of these sectors are energy or carbon intensive. The importers include top trading partners of India – constituting 1 percent or more of their total exports of the mentioned categories of goods. Appendix Table A2 list the Kyoto and non-Kyoto trading partners of India. Bilateral export data for the above mentioned categories of goods is retrieved from World Integrated Trade Solution (WITS), World Bank.

Figure 1 shows the trend in India's sectoral exports to Kyoto binding and non-Kyoto binding countries since 1998. At the starting of study period, the gap of exports to these groups of countries was minimal which has increased over the period of time, i.e. over the period of time India's exports to Kyoto binding countries has increased significantly in comparison to non-Kyoto binding countries.

Energy Price

The energy prices are obtained from Sato et al. (2015). For our analysis, we use Variable weights Energy Price Level (VEPL) based on market exchange rate, constant 2010 US$. Sato et al. (2015) obtained the price level by applying weighted arithmetic average with time varying variable weights of the fuel types. Underlying prices are net of inflation. The fuel mix in a sector depends on the technological changes, substitution possibilities etc. The VEPL represents the effective real energy price level of a particular sector in a particular country and point in time. As, the fuel consumption data used for weighting the fuel prices changes over time, the VEPL reflects any fuel-switching that occurs within a sector over time. We use VEPL at market exchange rate since we are dealing with international market. The other type of energy price is given by Fixed-Weight energy Price Index (FEPI). The FEPI captures only energy price changes that come from changes in fuel prices, and not through changes in the mix of fuel-mix. There is a possibility that VEPL prices have endogenous characteristics as industry specific shocks on output can impact the fuel consumption within sector and hence the sector level energy prices represented by VEPL. Therefore, regressions with VEPL based price as an explanatory variable could use the FEPI as an instrument, as FEPI prices are free from the endogeneity problem associated with fuel distribution (Linn, 2008; Sato et al., 2015).

Figure 2 presents a trend in VEPL in India and its Kyoto and non-Kyoto binding trading partners. We observe that generally the energy prices are higher in Kyoto binding countries relative to India but are lower in non-Kyoto binding countries. Since 2003 the energy prices are declining in India and after 2008 they are even lower than the non-Kyoto binding countries. This may be due to increasing energy efficiency of Indian industry since the early 1990s. Figure 3 depicts a negative relationship between the relative energy prices in India and its sectoral exports lending support to the conventional wisdom that as the relative prices of a factor of production goes up, the exports of that product declines due to increase in relative cost of production.

Relative Factor Ratio

The country level data for capital and labour is obtained from Penn world Tables, version 8 and World Development Indicators, respectively.

Climate Policy

This paper attempts to assess also the impact of climate policies adopted by the importers on the exports from India. The Climate policy being considered here is the Kyoto protocol. Kyoto status (ratification) of the importer countries is obtained from the UNFCCC homepage

Other Covariates

GDP (in constant US$) is obtained from the World Development Indicators (WDI) database. Bilateral time invariant measures vis-a-vis distance, contiguity, common language are taken from the CEPII distances database. The information of regional and bilateral agreements of India is retrieved from the WTO. Composite Institutional quality of the trading partners is captured by the regulatory quality index. This index is obtained from World Bank's World Governance Indicators (WGI). The indicators lie in the range of -2.5 and 2.5[4].

Table 1 represent the descriptive statistics of the main variables used in the analysis. At the mean level sectoral exports are higher for non-Kyoto binding countries relative to Kyoto binding countries, and standard deviation between is much higher than within for both the groups of countries. The energy prices represented by the variable VEPL are higher, at the mean level, for the Kyoto binding countries in comparison to the other countries. Here again we observe that within standard deviation is lower in comparison to between the sectors for both the groups of countries. This table also reveals that the regulatory quality, at the mean level, is higher in India's trading partners in comparison to its own regulatory quality.

4. Results and Discussion

Table 2 provides the estimates of equation (1) for the standardized sectoral exports from India. These regressions control for the time varying importer effects. In addition to this, it includes relevant multilateral resistance control variables (i.e., distance, contiguity, common language). Based on the literature of non-tariff trade costs, we also control for regulatory quality in India and in its importer countries to assess the impact of institutional quality on trade flows between them. We further control for relative factor endowment ratio i.e. capital to labour to empirically test existence of standard trade theories. A value equal to 1 shows equal factor ratio between the trading partners, reflecting similarity in preferences between the trading partners.

We begin by estimating the static version of equation (2); the results are reported in column I. This version includes time varying importer effects (multilateral resistances). However, it excludes the lags of the dependent variable and relative energy price differential. The coefficient of contemporaneous relative energy price is positive and statistically significant, contrary to basic economic theory and is in contrast to the findings of Aldy and Pizer (2015) and Sato and Dechezleprêtre (2015). However, the coefficients of standard gravity variables have expected signs. Kyoto ratification variable's coefficient is though negative, it is not statistically significant. These findings are in line with the findings of Olivero and Yotov (2012) and lend support to the idea that exclusion of dynamic features have less effect on time invariant variables, but significant impact on time variant variables. The regression specification error

[4]A statistical methodology known as an Unobserved Components Model is used for the index generation to (i) standardize the data from these very diverse sources into comparable units, (ii) construct an aggregate indicator of governance as a weighted average of the underlying source variables, and (iii) construct margins of error that reflect the unavoidable imprecision in measuring governance.

test (RESET) test for this version of the equation provides a high χ^2statistic of 8.7, disapproving the static OLS specification of equation 2.

Next, we introduce lags of the dependent variable and relative energy price to equation 2 and report the results in column II in Table 2. This version reflects positive impact of first two lags of the dependent variable, size adjusted current export levels, showing the presence of *persistence trade* effect. Moreover, we find that current relative energy price level does not impact the export levels, but the coefficient of first lag of relative energy price variables is negative and statistically significant which implies that there is stickiness in the sectoral exports of India to its trading partners. This finding concurs with Sato and Dechezleprêtre (2015). However, the coefficient of second lag is positive and statistically significant supporting the view of Olivero and Yotov (2012) that contemporaneous and dynamic effect of trade barriers are in opposite directions. Persistence effect on relative energy prices on Indian exports is negative, but statistically insignificant. Here we also find that the exporter's regulatory quality positively affects its exports, but the importer's regulatory quality has not impact on the export levels. The coefficient of Kyoto ratification variable though remains negative and statistically insignificant. Note that the inclusion of lagged covariate significantly improves overall adequacy of the model as is reflected from the RESET statistic (χ^2 = 2.01). Note that these results may be suffering from endogeneity bias since the energy prices and lagged values of exports could be endogenous.

Instrument variable models and system GMM models take care of endogeneity related to the choice of relative energy price and lag of dependent variables. As stated above, we use sectoral variable weight energy price levels (VEPL) to measure the impact of energy price differential between the trading partners to measure its impact on Indian exports. The VEPL takes into account the variation in the energy consumption across sectors and the choice of fuel mix adopted, and thus makes it an endogenous variable (Lovo et al. 2014). Technological change, fuel substitution and sector specific shocks on output demand could potentially affect the choice of fuel mix in a sector and thereby sectoral energy prices (Linn 2008). We use the Fixed-Weight energy Price Index (FEPI) and lags of Variable-weight Energy price level as instruments, as suggested by Linn (2008) and Sato and Dechezleprêtre (2015). FEPI is based on fixed weights and is less affected by the variation within a sector due to determinants of fuel mix in a particular sector and year.

Column III reports the results of instrumental variable (IV) model accounting for endogeneity of relative energy price variables. Instruments include FEPL based on 2010 fuel mix weights and lags of VEPL. As in the dynamic OLS model, lagged export levels positively impact current export levels of India. The relative energy price level hampers export competitiveness of India's industrial goods. For the IV 2SLS (1) (column III) model, we have used current and third lag of energy price differential due to identification problem. The third lag of energy price differential positively impacts export levels. This can be attributed to the substitution effect from energy input to non-energy inputs thereby an increase in the exports. This model passes the Sargan test of over identifying restrictions with a χ^2 value of 0.423. The IV 2SLS (2) (column IV) model provides similar results as far as export persistence effect is concerned. Contemporaneous energy price differential impact is though negative, it is weakly significant. The second lag of the energy price differential positively impacts export levels. However, presistence impact of energy price differential on the Indian exports is negative and statistically significant lending support to the argument that relative energy prices have persistence impact on export competitiveness of a country. The IV-2SLS (2) model is correctly specified as can be inferred from the RESET test χ^2 value of 0.01. Further, the Durbin-Hausman with χ^2 value of 1.759 reflects exogeneity of the energy price differential. IV-2SLS (1) and IV-2SLS (2) differs in the choice of instruments for the differential energy price variable.

Next, we focus on the results of Arellano-Bover (1995) /Blundell Bond's (1998) system-GMM estimator. In the System GMM model, lags of standardized exports and the energy price differential are used as instruments for the model. The results are reported in column V, wherein lagged values of exports impact the current exports positively. The model passes the Sargan-Hansen test for over identifying restrictions with a χ^2 value of 151.45. The Hansen test for exogeneity of instruments establishes correctness of the instruments. The Arellano-Bond test for autocorrelation in disturbances passes the test for second order serial correlation AR (2) with z = -1.39.

System GMM results shows the presence of export persistence effect; the coefficients of all three lags are positive and statistically significant. We also observe that regulatory quality in both the exporter and importers countries are equally important; we find the index of regulatory quality is positive and statistically significant. Relative factor ratio affects the exports from India to its trading partners negatively, but it is not statistically significant. Our main interest lies in the energy price differential variable. Current value of relative energy prices though negatively affects the exports from India, it is not statistically significant, supporting the hypothesis of stickiness in level of sectoral exports with respect to differential energy prices. This finding is consistent with finding of recent literature (e.g., Olivero and Yotov, 2012; Sato and Dechezleprêtre, 2015). However, we observe a presence of *persistence of energy price differential effect*. The coefficient of the persistence differential energy price variable is -0.095 and it is statistically significant implying that a 1 percent increase in relative sectoral energy prices on average affects the Indian sectoral exports by 0.1 percent varying from 0.094 for chemicals to 0.14 for the non-ferrous metals (Figure 4). This finding is consistent with the findings of Aldy and Pizer (2015) and Sato and Dechezleprêtre (2015), supporting the argument that the concerns about carbon leakage are not unfounded but are exaggerated. Climate policy should not be designed based on the fears of carbon leakage.

We also find that the coefficient of the Kyoto ratification variable, though consistently negative in all the specification, is statistically significant. This finding may be interpreted as the presence of negative carbon leakage. But the presence of negative persistence effect of differential energy prices imply that Kyoto Protocol was not effective in increasing the relative energy or carbon prices in the ratifying countries. Indian exports have continuously been increasing implying that trade is determined more by the factors such as exchange rates, transport costs, trade agreements, and relative costs of labour, capital and other input costs relative to carbon prices even to the Kyoto Protocol ratifying countries (Figure 1).

5. Conclusion

Unilateral climate policies such as Kyoto Protocol are supposed to compromise the trade competitiveness of host countries and raise concerns of carbon leakage. Since the empirical evidence is not conclusive, this paper measures the impact of differential energy prices at sectoral level exports of a developing country, India. This is also important since future climate policies are not going to be limited to developed countries. India has already pledged to achieve a reduction in carbon intensity of GDP by about 20 percent by 2020 relative to the level of 2005 and climate policies are supposed to increase the effective energy prices.

Since the data on the stringency of climate policies is scant and incomparable across countries, we use energy price differential between trading partners as a proxy for carbon mitigation policy. We evaluate the impact of these industrial energy price differences on Indian exports of 11 energy/carbon intensive sectors over the period of 1998 to 2009. We apply dynamic gravity model proposed by Olivero and Yotov (2012). This model nests the conventional static model and help in estimating persistence trade and protection effects. We take care of econometric problems that generally arise in the estimation of gravity model with an aim to have robust and consistent estimates of the impact of energy price differential. We use system GMM estimator to account for dynamic concerns, and size adjusted exports is used as dependent variable to take care of the heteroscedasticity problem.

We find a presence of persistence trade and energy price differential effects. We observe an absence of contemporaneous energy price differential effect on Indian exports. The persistence effects of relative industrial energy prices are negative supporting the conventional wisdom of trade. But the magnitude of this persistence effect is small. For a 10 percent increase in relative industrial energy price, Indian industrial exports get reduced by about 1 percent, and this effect varies from sector to sector depending on energy intensity of the sector. Higher the energy intensity of a sector larger would be the effect. The effect is largest for the non-ferrous metal sector of the magnitude of about 1.4 percent for a 10 percent increase in relative energy prices followed by the machinery sector (1.3 percent).

Results of the study suggest that the concerns of carbon leakage are though not unfounded, but are largely overplayed in conformity of the existing literature. Trading competitiveness of countries is largely linked to institutional quality, infrastructure, proximity to customers, and capital and labor costs. Therefore, carbon leakage concerns should not dictate future climate policy.

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Table 1: Descriptive Statistics

		All trading partners				Kyoto binding countries				Non-Kyoto binding countries			
Variable		Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Real exports (Million USD)	Overall	2.65	3.26	0.17	17.00	2.07	1.27	0.21	5.31	3.53	4.81	0.17	17.00
	Between		3.03	0.71	13.50		1.05	0.72	3.82		4.66	0.71	13.50
	Within		1.21	-2.20	6.33		0.79	0.48	4.77		1.66	-1.32	7.21
Energy Prices exporter (USD/Tonne Equivalent of Oil)	Overall	558.38	60.17	427.55	638.19	557.68	59.97	427.55	638.19	559.42	60.92	427.55	638.19
	Between		4.86	555.94	570.49		4.49	556.20	570.49		5.57	555.94	567.56
	Within		59.98	418.37	640.63		59.83	429.04	639.68		60.70	419.42	641.67
Energy Prices importer (USD/Tonne Equivalent of Oil)	Overall	618.58	271.87	206.31	1708.96	704.86	257.02	359.80	1708.96	488.49	241.69	206.31	1262.96
	Between		246.76	226.07	1206.24		214.99	414.18	1206.24		239.48	226.07	957.48
	Within		136.25	121.80	1121.31		158.93	208.07	1207.58		93.36	102.21	793.97
Factor ratio exporter	Overall	0.01	0.00	0.01	0.02	0.01	0.00	0.01	0.02	0.01	0.00	0.01	0.02
	Between		0.00	0.01	0.01		0.00	0.01	0.01		0.00	0.01	0.01
	Within		0.00	0.01	0.02		0.00	0.01	0.02		0.00	0.01	0.02
Factor ratio importer	Overall	0.15	0.09	0.01	0.37	0.19	0.07	0.04	0.37	0.09	0.08	0.01	0.27
	Between		0.09	0.02	0.29		0.07	0.07	0.29		0.08	0.02	0.24
	Within		0.03	0.09	0.24		0.03	0.14	0.28		0.02	0.03	0.15
Regulatory quality exporter	Overall	-0.31	0.08	-0.41	-0.16	-0.31	0.08	-0.41	-0.16	-0.31	0.08	-0.41	-0.16
	Between		0.00	-0.31	-0.30		0.00	-0.31	-0.30		0.00	-0.31	-0.31
	Within		0.08	-0.41	-0.16		0.08	-0.41	-0.16		0.08	-0.41	-0.16
Regulatory quality importer	Overall	0.85	0.74	-0.78	2.08	1.16	0.61	-0.41	2.08	0.38	0.67	-0.78	1.74
	Between		0.75	-0.45	1.80		0.68	-0.29	1.80		0.68	-0.45	1.58
	Within		0.14	0.34	1.13		0.14	0.65	1.44		0.15	-0.04	0.65

Table2: Estimates of Dynamic Gravity Model: Sectoral Exports Results

	(I)	(II)	(III)	(IV)	(V)
	Static OLS	Dynamic OLS	IV-2SLS (1)	IV-2SLS (2)	SYS-GMM
Size Adjusted $Exports_{t-1}$	-	0.729^{***} (28.35)	0.726^{***} (28.49)	0.698^{***} (26.50)	0.760^{***} (138.05)
Size Adjusted $Exports_{t-2}$	-	0.242^{***} (9.50)	0.247^{***} (9.77)	0.180^{***} (5.89)	0.0789^{***} (11.41)
Size Adjusted $Exports_{t-3}$	-	-	-	0.0975^{***} (3.95)	0.138^{***} (24.61)
Kyoto ratification	-0.123 (-0.60)	-0.0909 (-1.45)	-0.0697 (-1.08)	-0.0935 (-1.37)	-0.0922^{***} (-7.71)
Energy Price Differential	0.770^{***} (4.97)	0.0269 (0.18)	-0.415^{***} (-2.98)	-0.959 (-1.55)	-0.0244 (-1.52)
Energy Price $Differential_{t-1}$	-	-0.312* (-1.67)	-	0.580 (0.96)	-0.166^{***} (-8.31)
Energy Price $Differential_{t-2}$	-	0.400^{**} (2.61)	-	0.359^{**} (2.24)	0.405^{***} (16.76)
Energy Price $Differential_{t-3}$	-	-0.169 (-1.64)	0.348^{**} (2.52)	-0.0976 (-0.88)	-0.310^{***} (-16.72)
Factor Ratio	0.616 (0.68)	0.371 (1.34)	0.374 (1.36)	0.416 (1.50)	-0.0383 (-1.09)
Exporter regulatory quality	0.00270 (0.00)	0.767^{***} (2.95)	0.937^{***} (3.50)	0.983^{***} (3.28)	0.392^{***} (10.03)
Importer regulatory quality	0.285 (1.25)	0.0512 (0.74)	0.0821 (1.14)	0.0757 (1.02)	0.0281^{**} (2.40)
Number of Observations	1647	1410	1356	1356	1329
Constant	-9.419^{***} (-4.33)	1.006 (1.49)	1.549^{**} (2.31)	2.100^{**} (2.20)	-0.517^{***} (-9.25)
Time Varying fixed effects	Yes	Yes	Yes	Yes	-
Bilateral Time invariant factors	Yes	Yes	Yes	Yes	Yes
Regional/Bilateral Trade Agreements	Yes	Yes	Yes	Yes	Yes
RESET test χ^2 (p value)	8.70 (0.000)	2.01 (0.110)	-	0.01 (0.922)	-
Sargan-Hansen Test	-	-	0.423 (0.515)	-	151.36 (0.224)
Instrument Exogenity Test (Durbin-Hausman test)	-	-	-	2.508 (0.113)	-
Instrument Exogenity Test (Hansen test)	-	-	-	-	9.96 (0.933)

Arellano-Bond test for AR(2) Z statistic (p value)	-	-	-	-	0.87 (0.386)
Persistence Impact of Energy Price Difference (t-statistics)	-	-0.055 (-1.13)	-0.067 (-1.37)	-0.117** (-2.14)	-0.095*** (-10.23)

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Figure 1: Trend in sectoral exports of India

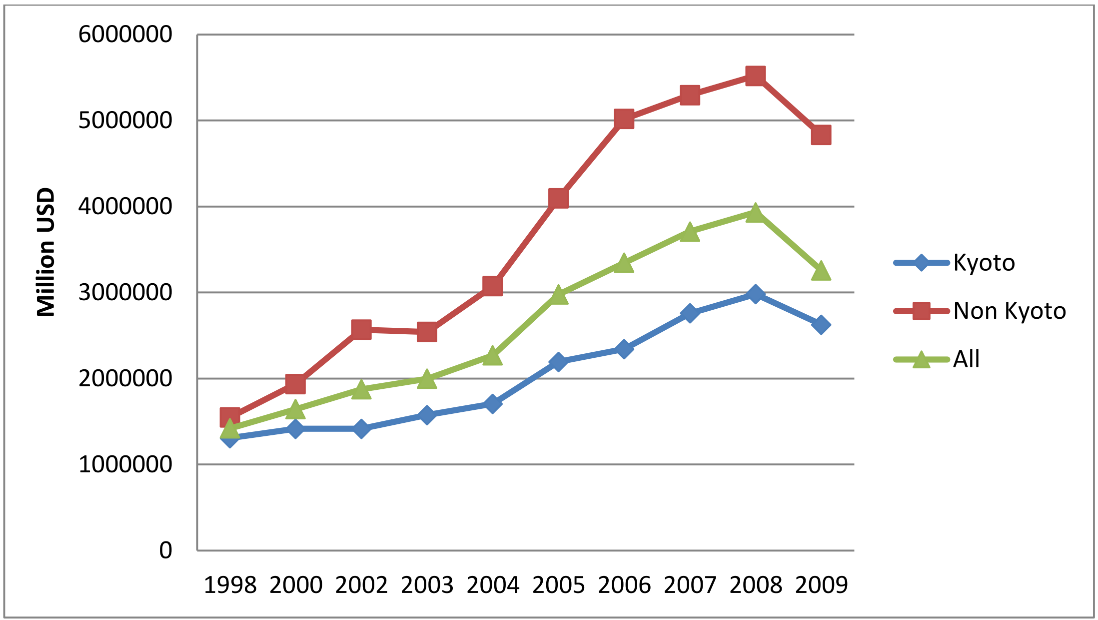


Figure 2: Trend in effective energy prices

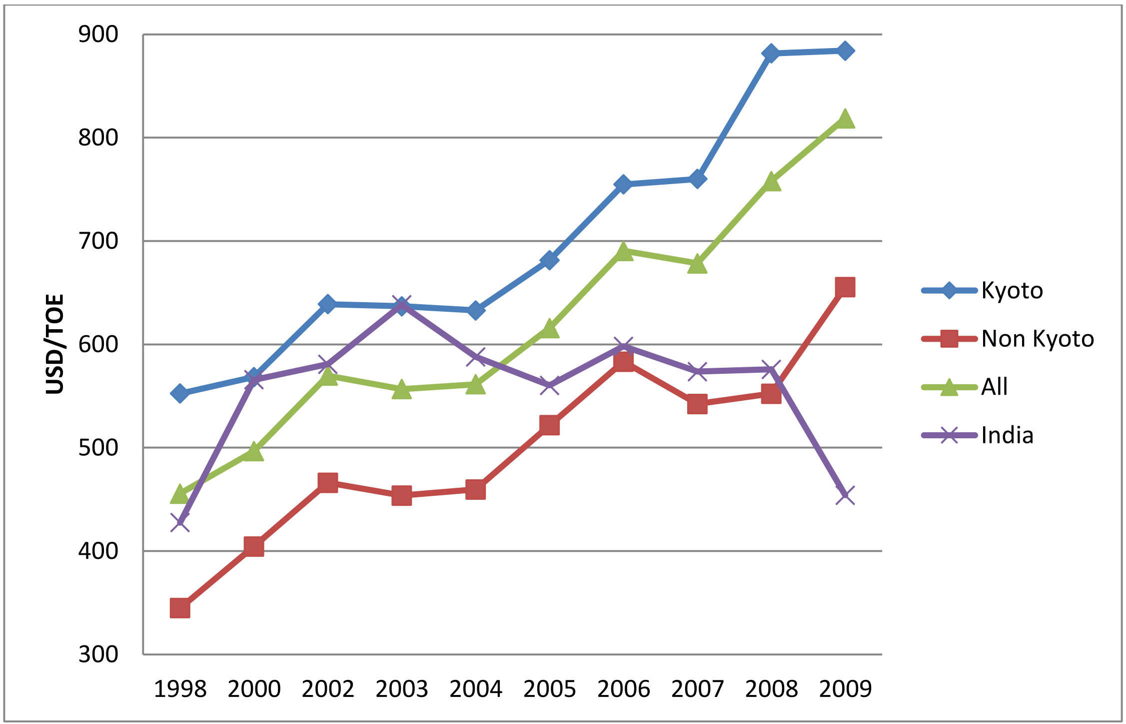


Figure 3: Relative energy prices and sectoral exports

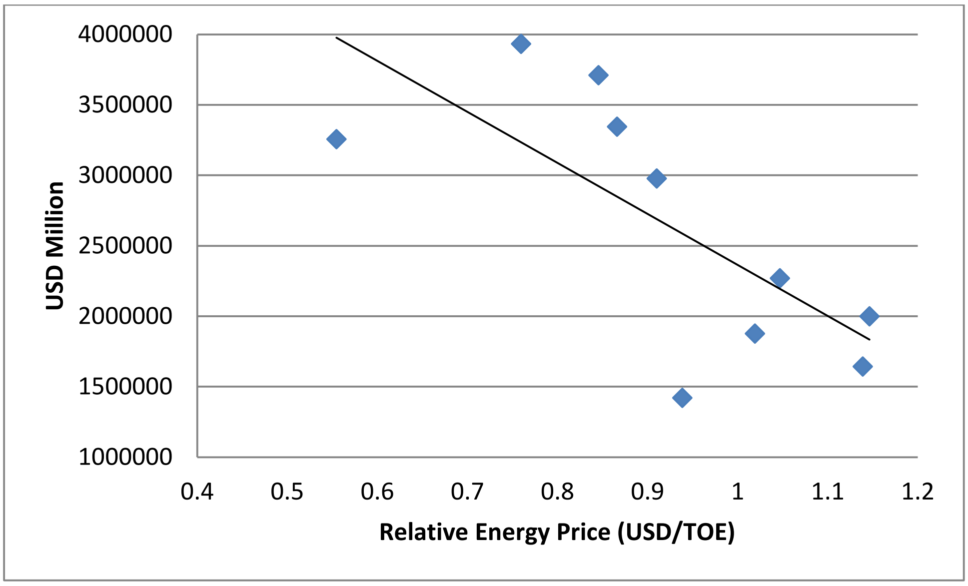
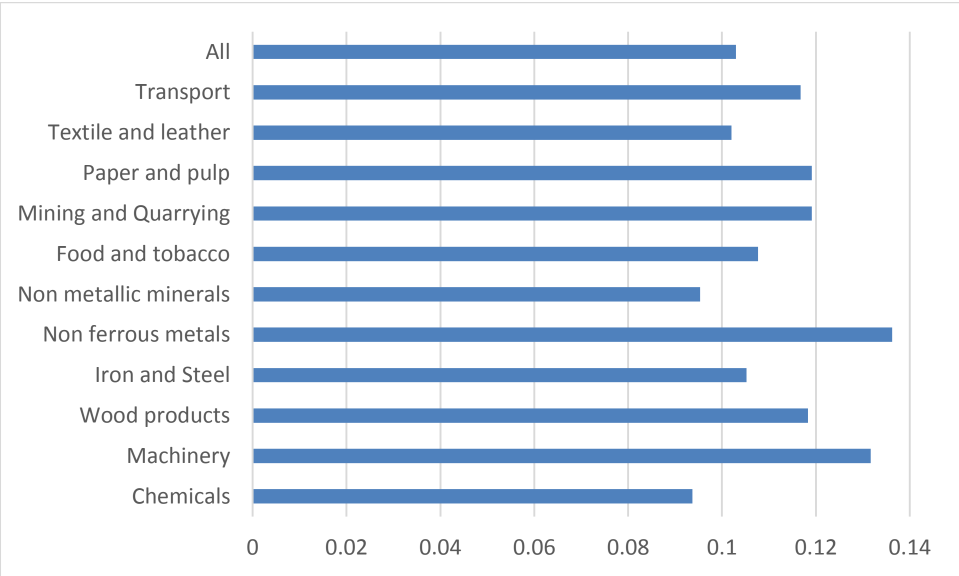


Figure 4: Persistence energy price differential elasticity of Indian exports



Appendix

Table A1: Industrial goods

Sector	**Classification (ISIC revsion 3)**
Chemicals	24
Machinery	29
Wood products	20
Iron and Steel	271
Non-ferrous metals	242, 2432
Non-metallic minerals	272
Food and tobacco	15, 16
Mining and Quarrying	10, 12, 13, 14
Paper and pulp	21, 22
Textile and leather	17, 19
Transport	29, 30

Table A2: India's trading partners for sectoral exports

Kyoto Trading Partners	**Non Kyoto Trading Partners**
Australia	Brazil
Belgium	China
France	Indonesia
Germany	Korea, Rep.
Italy	South Africa
Japan	Thailand
Netherlands	United States
Russian Federation	
Turkey	
United Kingdom	