ANALYSIS
https://doi.org/10.1038/s41893-018-0113-1

nature sustainability

Tariff reduction on renewables inputs for European decarbonization

Svetlana Fedoseeva[1] and Rodrigo Zeidan[2,3]*

Climate action is an integral part of the Sustainable Development Goals agreed by all 193 United Nations member states. We show that lifting European Union import tariffs on some inputs used to produce renewable energy could lessen Europe's carbon footprint, improving the likelihood that the region meets the targets of the Paris Agreement and the Sustainable Development Goals. The results of a panel regression analysis with detailed product-level data indicate that eliminating the tariffs on 11 intermediate inputs may help to offset fossil fuel consumption driven by growth in economic activity. Abolishing the tariff on a single product—cylindrical roller bearings, used in the manufacturing of wind turbines—would probably bring the most benefit, cancelling out the expansion in demand for fossil fuels otherwise expected from 1–4% European gross domestic product growth (46,000–236,000 tonnes of oil equivalent per member state).

Adjusting how we produce and consume energy is fundamental in reducing the impact of climate change. More importantly, poverty, energy and food security[1], and climate change[2,3] are becoming increasingly correlated. Poor communities are less resilient to climate shock, and our ability to survive and thrive depends on curbing CO_2 emissions (that is, decarbonization), limiting the effects of global warming. Renewables, which are projected to be the fastest growing segment of the energy industry[4] and are the focus of this article, have a large role to play in decarbonization.

For European countries, meeting the targets of the Paris Agreement and Sustainable Development Goals is impossible without a transition from hydrocarbons to renewables; this, combined with increasing energy efficiency alone, can contribute 90% of the CO_2 emissions reduction required by 2050[5]. As it stands, fossil fuels make up the largest share of the European Union (EU) energy mix. Of all fossil fuels, petroleum products are the most important energy source for the EU. Today, renewables account for approximately 15% of total energy consumption and 30% of generation in the region. The use of renewable energy sources is spread unevenly throughout the continent; in Sweden, it is almost 40%, while Luxembourg and Malta are far away from their 2020 targets (around 5 and 3%, respectively).

Unresolved issues related to the production, conservation and transportation of renewable energy significantly delay the green transition. Barriers to growth include, but are not limited to, obsolescence and high maintenance costs[6], infrastructure flaws[7], vested interests, coordination issues[8], the strong bond between fossil fuels consumption and economic growth[9], and divergence in terms of public research and development-based knowledge build-up in renewable energy technology[10,11].

In Europe, any action to increase the trade in renewable inputs should be in line with the EU's sustainable development and 'Trade for All' strategies. Trade for All aims to step up liberalization in areas key to EU competitiveness, such as energy and raw materials[12]. Given the numerous barriers to decarbonization in Europe, steps to promote renewables that are cost effective should be a priority of public authorities. Here, we estimate the potential benefits of elimination of tariffs on some intermediate goods related to renewables production. Trade growth on capital goods has direct and indirect economic costs and benefits. Direct benefits come from reductions in the relative price of renewables vis a vis fossil fuels. Indirect benefits arise from lower research and development costs and the acceleration of innovation in the industry. Recent research shows how research and development subsidies seem preferable to demand subsidies[13], estimating the large effects of green transition[14], and proposing trade openness in the context of African countries[15], where transition is pitched as an environmental imperative[16].

We argue that a tariff elimination in selected products that can speed up decarbonization is politically viable, since reducing tariffs on a few products appears to be easier than altering subsidies, changing carbon taxes or setting cap and trade systems on a national/supranational level. More details on the political viability of the policy change we propose are provided in the Discussion.

Results

The regression model and individual variables used in the analysis are described in the Methods. We hypothesize that allowing freer trade on inputs should decrease the cost of renewables production and thus reduce demand for fossil fuels by the substitution effect—if renewables become relatively cheaper, the use of fossil fuels declines. Fossil fuel consumption is closely linked to economic performance[17]: when the region's economic activity picks up, fossil fuel consumption usually increases. Our results indicate that lifting tariffs for some renewable inputs can reduce fossil fuels demand by 46,000–236,000 tonnes of oil equivalent (TOE) per EU country, which is comparable to offsetting the positive effect of 1–4% gross domestic product (GDP) growth on fossil fuel consumption. Strategies that limit the impact of economic growth on fossil fuel demand are particularly important for Europe, as greener economic growth would diminish the downsides of higher economic activity when we consider the economic growth–environmental impact tradeoff.

We identify 11 inputs for which import tariff liberalization could contribute to a decline in fossil fuel demand (the full list of considered inputs is provided in Supplementary Table 1). Some intermediate products on our input list may also be used in fossil fuel

[1]Institute for Agricultural Policy and Market Research, University of Giessen, Giessen, Germany. [2]New York University Shanghai, Shanghai, China. [3]Fundação Dom Cabral, Nova Lima, Brazil. *e-mail: rodrigo.zeidan@nyu.edu

Table 1 | Selected renewable technology-related determinants of petroleum products consumption

Product (variable name)	Gross consumption		Per-capita consumption	
	Ordinary least squares model	Robust least squares model	Ordinary least squares model	Robust least squares model
Gas-cleaning machinery (PB4)	0.030*** (0.012)	0.011 (0.009)	0.029*** (0.011)	0.020** (0.010)
Aluminium gasifier (PB7)	0.014** (0.006)	0.012*** (0.004)	0.013** (0.006)	0.017*** (0.005)
Receiver tube element of iron (PR1)	0.001 (0.014)	0.016 (0.012)	0.017* (0.010)	0.024** (0.010)
Receiver tube element of stainless steel (PR2)	0.018** (0.008)	0.018*** (0.007)	0.015** (0.008)	0.021*** (0.008)
Central receiver (PR10)	0.026** (0.012)	0.005 (0.009)	0.033*** (0.011)	0.019** (0.009)
Power conversion engine without generator (PR12)	0.006 (0.005)	0.002 (0.004)	0.011** (0.005)	0.009** (0.004)
Unframed glass silver mirror (PS1)	0.025** (0.011)	0.027*** (0.009)	0.025*** (0.010)	0.024** (0.011)
Inverter (PS13)	0.017* (0.009)	0.020** (0.009)	0.015 (0.010)	0.010 (0.010)
Ball bearing (PW7)	0.030*** (0.012)	0.014 (0.010)	0.008 (0.011)	0.006 (0.011)
Other cylindrical roller bearings (PW11)	0.047*** (0.016)	0.048*** (0.012)	0.030** (0.015)	0.039*** (0.013)
Electrical control equipment (exceeding 1,000 V) (PW15)	0.022** (0.009)	0.017** (0.008)	0.007 (0.009)	0.008 (0.009)

The effects of each intermediate input's price reduction associated with a 1% tariff decrease are shown in terms of elasticities (the persentage that petroleum products consumption decreases if renewable inputs become cheaper). Robust standard errors are reported in parentheses. *$P<0.10$; **$P<0.05$; ***$P<0.01$.

production and it would be possible that tariff reductions for such inputs could increase the use of non-renewable energy sources. To avoid this issue, we only discuss the inputs for which tariff liberalization negatively affects fossil fuel consumption. The effects of a tariff elimination are shown in terms of elasticities; that is, the percentage that fossil fuel consumption decreases if renewable inputs become cheaper. The elasticities are reported in Table 1 if—at least in one block of gross or per-capita models for petroleum products consumption (full results are reported in Supplementary Table 2)—the coefficients from both specifications are statistically significant.

Table 2 lists the average elasticities as well as joint confidence intervals (CIs) from the four models for the variables reported above, as well as the current average rate of the import tariff and the resulting possible range of the impact of its elimination on petroleum consumption. Our results are fundamentally static in nature, and the final impact might be higher than presented here, since the relative decline in renewable costs may incentivize research and development and further adoption of this kind of energy throughout the economy. Below, 'we only focus on the results for intermediate inputs with coefficients that were statistically significant in all four models (highlighted in bold in Table 2). We discuss our results in terms of offsetting the possible increase in fossil fuel consumptions related to economic growth. While the effect of tariff liberalization on fossil fuel consumption would remain intact even in the absence of GDP changes, the growth–environment tradeoff is more acute when national economies are growing—the entire 'de-growth' movement is based on the idea that since economic growth brings harmful environmental impacts, countries should question economic growth as a relevant macroeconomic outcome[18].

Of the four highlighted intermediate inputs in Table 2, only one does not have any tariff imposed on its imports. The other three products face import duties that range from 4–8%.

Table 2 | Expected effects of tariff elimination for selected renewable inputs

Product (variable name)	Average elasticity	Joint CI (95%)		Tariff	Impact of tariff abolition		
		Lower bound	Upper bound		Average	Lower bound	Upper bound
Gas-cleaning machinery (PB4)	0.023	−0.006	0.053	1.7	0.038	−0.010	0.090
Aluminium gasifier (PB7)	**0.014**	**0.001**	**0.027**	**6.0**	**0.085**	**0.007**	**0.160**
Receiver tube element of iron (PR1)	0.014	−0.027	0.044	0	0	0	0
Receiver tube element of stainless steel (PR2)	**0.018**	**0**	**0.036**	**0**	**0**	**0**	**0**
Central receiver (PR10)	0.021	−0.012	0.055	2.4	0.050	−0.028	0.132
Power conversion engine without generator (PR12)	0.007	−0.006	0.021	4.2	0.030	−0.026	0.089
Unframed glass silver mirror (PS1)	**0.025**	**0.003**	**0.046**	**4.0**	**0.102**	**0.013**	**0.184**
Inverter (PS13)	0.015	−0.010	0.036	3.3	0.051	−0.032	0.120
Ball bearing (PW7)	0.014	−0.016	0.054	8.0	0.115	−0.125	0.430
Other cylindrical roller bearings (PW11)	**0.041**	**0.001**	**0.080**	**8.0**	**0.329**	**0.007**	**0.638**
Electrical control equipment (exceeding 1,000 V) (PW15)	0.014	−0.010	0.040	2.1	0.028	−0.021	0.085

Impacts of tariff elimination were calculated as a product of the average elasticity, lower and upper bounds of the joint CI, and tariff. Intermediate inputs with coefficients that were statistically significant in all four models are shown in bold.

For all the models, the highest reduction in petroleum product consumption due to the elimination of an import tariff is expected from cylindrical roller bearings. The average effect of import tariff elimination for this product is large enough to offset petroleum product consumption related to GDP growth of 0.5% in the EU (other things being equal). On the upper bound of the CI, the effect is almost twice as high (the rough equivalent of 145,000 TOE per country). When total fossils are considered as a dependent variable (Supplementary Table 3), cylindrical roller bearings also seem to be the product for which import tariff elimination could most effectively facilitate the reduction of fossil fuels consumption. The average GDP coefficient is 0.119 (CI: 0.017–0.224). On average, this implies that the increase in imports from the tariff elimination for cylindrical roller bearings can reduce fossil fuels consumption equivalent to a 2% GDP increase. On the lower bound of the CI, liberalization of imports can lead to a fossil consumption decline of approximately 0.10%, which is comparable to the fossil fuels consumption increase resulting from a 1% GDP increase in all of Europe. On the upper bound, the effect is over 0.49%, and the equivalent of a 4% GDP increase (that is, it would offset all expected European GDP growth for 2018 and 2019). The possible fossil demand reduction is in the range of 46,000–236,000 TOE on average per EU member state. Summing up, there are potential gains from the tariff reduction of a single product related to renewables energy.

For other products, the effects are statistically significant but not as large. On the lower bound of the CI, the elimination of the import tariff for aluminium containers used in bio gasifiers would result in a petroleum products consumption decline of 0.007%. On the upper bound, the effect is twice as high. The average effect of a price reduction of 6% for gasifier containers (compared with the current tariff rate) would be comparable to an average effect of a 4% increase in the import price of crude oil. We expect an effect similar in magnitude from the elimination of the import tariff for unframed silver mirrors used in solar reflectors. Although the existing import tariff here is lower (4%), the estimated coefficient is larger, with a 1% change in the input price having a higher impact on fuel consumption.

Discussion

In the past two decades, the global society has made progress in eradicating poverty and hunger, as well as fostering access to basic education, sanitation and health coverage[19]. Yet, such progress might be reversed by our inability to adapt to and mitigate climate change impacts, which form the core of the more recent Sustainable Development Goals. Out of the 17 Sustainable Development Goals, almost half are directly linked to issues of energy and climate action, while the rest bear some relation to these issues. This is why policies that are relatively easy to implement and could improve environmental outcomes should be prioritized.

In the present case, we propose the liberalization of tariffs on selected inputs for renewables, which should shift energy use from fossil fuels towards green energy, helping Europe meet the Sustainable Development Goals. However, this policy, as with all economic policies, brings potential costs. European producers of similar goods may lose out because of more intense competition, and vested interests of affected groups might be potential obstacles to tariff changes. Nevertheless, most developed countries have been more successful at reducing tariffs than reducing direct subsidies and tax holidays[20]. In the EU, both trade liberalization and a push for renewable energy are part of the recent mission statement of the European Commission (Trade for All). The European Commission legislates on trade matters and represents the EU's interests on behalf of its member states. The political restrictions in both the EU and United States are clear: unilateral tariff reductions can be implemented without the approval of national legislative bodies. American presidents tend to use the stroke of a pen[21] to change tariff duties, as they can negotiate trade agreements through their fast-track authority[22]. The European Commission also exercises its authority on trade policy without major constraints; in 2017, it reduced the minimum import prices for Chinese solar panels sold in Europe, and in 2018, it published a list of US products for potential re-balancing tariff increases as a response to the American threat of imposing higher tariffs on European exports.

Following the business-as-usual scenario, and burning fossil fuels at the current rate, would lead to devastating effects on the entire ecosystem[23]. Setting a universal CO_2 cap might be the best option to reduce the CO_2 concentration[24], but this remains unfeasible in the near future. Therefore, all alternative measures to promote the transition from fossil fuels to renewables should be considered. Eliminating the import tariffs for renewable inputs is a potentially low-hanging fruit option for policymakers. It can speed up the energy transition to greener technologies, shifting market forces towards reducing, instead of increasing, CO_2 emissions as European economies recover from weak economic activity. More importantly, this policy change should improve the likelihood that Europe meets the Paris Agreement targets and the Sustainable Development Goals.

Methods

The model. The identification strategy comes from a classic reduced-form demand model for a panel of EU-27 countries, in which fossil fuel consumption is a function of income and prices[25] over the 1990–2016 period. The other main variables are: exchange rates[26] (given that a fair share of fossil fuels are imported), electricity consumption[27], country effects to account for cross-country heterogeneity in resource abundance and energy use, and time effects to account for technological progress[28] and all common shocks over time. To differentiate between the price effects of various hydrocarbonate products, we include, besides coal and gas, import prices for disaggregated petroleum products. Our main methodological contribution is incorporating into the model the vector of prices for intermediate products used in renewable energy production. The theoretical rationale for the inclusion of import prices for renewable technology inputs is that lower import prices for intermediate products reduce the costs of building renewable energy grids, which in turn lowers renewable energy prices. Once renewable energy becomes relatively cheap, part of energy demand shifts away from fossil fuels. The elimination of a tariff on an input is equivalent to a cost reduction for green energy production. Hence, the price elasticity of renewable inputs can tell us the extent to which the demand for fossil fuels can be altered by a 1% decline in input prices due to, for example, free(er) trade. The empirical specification we bring to the data is

$$\begin{aligned} X_{j,it} = {} & a_{j,0} + a_{j,1}\mathrm{GDP}_{it} + a_{j,2}\mathrm{RER}_{it} + a_{j,3}\mathrm{ELEC}_{it} + a_{j,4}\mathrm{UV}_{2701_{it}} \\ & + a_{j,5}\mathrm{UV}_{2709_{it}} + a_{j,6}\mathrm{UV}_{2710_{it}} + a_{j,7}\mathrm{UV}_{2711_{it}} \\ & + a_{j,8}\mathrm{UV}_{2712_t} + \gamma\mathbf{P}_k + \mu_i + \psi_t + e_{j,it} \end{aligned}$$

All variables enter the estimations in logs and the estimated coefficients are elasticities. Here, $X_{j,it}$ refers to the consumption of fossil fuel j measured in thousand TOE for the entire population or per capita in a country i at time t; a is a regression constant; e is a residual term. GDP is the real GDP in constant prices of 2010, expressed in the national currency of the respective EU countries (divided by the population in the per-capita models). RER is the real exchange rate measured in units of local currency per US dollar; hence, an increase in the value corresponds to a European currency depreciation against the dollar. Exchange rates are adjusted by each country's inflation index. ELEC stands for the (per-capita) electrical energy consumption measured in thousand TOE. UV_{2701}, UV_{2709}, UV_{2710}, UV_{2711} and UV_{2712} are the unit values of solid fuels, crude and refined oil products, gas and petroleum jelly imports from the international market, as included in Harmonized System codes 2701, 2709, 2710, 2711 and 2712, respectively, measured in US dollars per kg. μ_i and ψ_t are country and time fixed effects. $\mathbf{P}_k$ is the vector of import unit values for intermediates used in the production of renewable energy, where k refers to a renewable technology that uses the inputs (solar, wind, biomass or mixed). The import prices of inputs required for the production of renewable energy are approximated by their unit values. Relevant inputs are selected based on Wind[29], who lists the climate mitigation goods available on a commercial basis at a six-digit level of Harmonized System classification. Exclusion of double entries leaves us with 73 products, relevant for solar (13), wind (23) and biomass (15) production or more than one energy type (22). These inputs are presented in Supplementary Table 1 along with their brief description, the major source country for the EU imports and its share in total imports, as well as import tariffs for each group matched to individual Harmonized System codes from the United Nations Conference on Trade and Development (UNCTAD) Trade Analysis Information System (TRAINS) database. In the empirical part, we omit the input prices for which data had many missing observations. This leaves us with 54 inputs. Import tariffs for these products range from 0–8% (the highest tariffs are in the wind power-related group of products). However, one should keep in mind that some solar technology-related products (photovoltaic modules and cells, as well as solar glass) from China faced additional anti-dumping duties in the sample period that were not reflected in import tariffs. Since we do not have firm-level import data, we cannot disaggregate between various importers that face numerous barriers besides import tariffs. These price gaps are not reflected in the data. As a result, the effects of solar inputs prices on fossil consumption might be biased downwards. Finally, given that even at six-digit precision, the Harmonized System groups cover at times very different products, it might well be the case that some inputs relevant for renewables production also matter for the fossil fuel industry. In this case, we expect to observe a negative sign for the coefficients related to import prices. Since the information on which part of inputs is actually used to derive a particular type of energy is not available, we are mostly interested in inputs whose prices positively affect the final consumption of fossil fuels. This implies that the tariff elimination that acts as a price reduction affects fossil fuel consumption negatively.

Our empirical specification represents the cointegrating relationship between variables of the model, which we estimate by means of panel ordinary and robust least squares methods to account for potential outliers in dependent variables, as is standard in the types of models we are estimating. Supplementary Table 2 reports the results for models with petroleum products consumption as a dependent variable. Supplementary Table 3 shows the results for total fossil consumption. All models pass cointegration and stability tests.

Limitations. Our model is a statistic reduced-form econometric specification of energy demand. While it does well in quantifying ceteris paribus effects (those that assume an unchanging background) and provides us with results that are robust to sample adjustments, the model does not incorporate all the factors that may be relevant for energy markets at large. Our approach does not deal with features such as the dynamic spillover effects from other sectors of the economy or the interacting effects of alternative climate policies. Investigating all probable paths would imply a much more complex model (probably a computable general equilibrium model) and we encourage future research to investigate this issue further. Our major goal is to raise the attention to a politically viable way of reducing fossil fuels consumption through targeted elimination of individual tariffs for renewable inputs.

Code availability. The work files used in the econometric analysis are available from the corresponding author upon request.

Data availability. All data were sourced from publicly available databanks, including Eurostat, the Organisation for Economic Co-operation and Development (OECD), UN Comtrade and UNCTAD TRAINS. Petroleum and fossil fuel consumption were defined as the gross inland consumption of total petroleum divided by all products (in thousand TOE). These data were sourced from Eurostat (nrg_100a). Per-capita numbers were obtained by dividing the gross consumption by population numbers (demo_pjan). GDP was defined as the GDP calculated through the output approach in constant prices of 2010, measured in millions of local currency. These data were sourced from OECD. Stat (national accounts). Per-capita numbers were obtained by dividing the GDP by population numbers. Real exchange rates were calculated using Euro/European currency unit exchange rates and conversion factors (ert_bil_eur_a) (US dollar/local currency unit multiplied by conversion factor). These numbers were then adjusted based on consumer prices (all items) reported by OECD. Stat (prices and purchasing power parity). Electricity consumption data were sourced from Eurostat (nrg_105a), where electricity consumption is defined as the final energy consumption (electrical energy) in thousand TOE. Per-capita numbers were obtained by dividing these values by population numbers. Import prices for energy products, including coal, crude and refined oil, gas, and petroleum jelly, were calculated by dividing the total import values (in US dollars) by the quantities (in kg) for the products defined under Harmonized System codes 2701, 2709, 2710, 2711 and 2712 in UN Comtrade. Import prices for renewable intermediate inputs were calculated in a similar way for all the products listed in Supplementary Table 1, using the import values and quantities in UN Comtrade. Information on import tariffs for intermediate inputs was obtained from UNCTAD TRAINS. Supplementary Table 4 provides basic descriptive statistics for all variables.

Received: 27 March 2018; Accepted: 5 July 2018;
Published online: 14 August 2018

References

1. Jovanović, M. *Heating Up* (International Monetary Fund, 2017); http://www.imf.org/external/pubs/ft/fandd/2017/12/picture.htm
2. Sadorsky, P. Renewable energy consumption and income in emerging economies. *Energy Policy* **37**, 4021–4028 (2009).
3. Lomborg, B. Climate-change policies can be punishing for the poor. *The Wall Street Journal* (4 January 2018); https://www.wsj.com/articles/climate-change-policies-can-be-punishing-for-the-poor-1515110743
4. REN21 *Renewables 2017: Global Status Report* (2017); http://www.ren21.net/gsr-2017/
5. *Perspectives for the Energy Transition: Investment Needs for a Low-Carbon Energy System* (International Renewable Energy Agency, 2018); http://www.irena.org/publications/2017/Mar/Perspectives-for-the-energy-transition-Investment-needs-for-a-low-carbon-energy-system
6. Ziegler, L., Gonzalez, E., Rubert, T., Smolka, U. & Melero, J. J. Lifetime extension of onshore wind turbines: a review covering Germany, Spain, Denmark, and the UK. *Renew. Sustain. Energy Rev.* **82**, 1261–1271 (2018).
7. Sinn, H. W. Buffering volatility: a study on the limits of Germany's energy revolution. *Eur. Econ. Rev.* **99**, 130–150 (2017).
8. Cherp, A., Vinichenko, V., Jewell, J., Suzuki, M. & Antal, M. Comparing electricity transitions: a historical analysis of nuclear, wind and solar power in Germany and Japan. *Energy Policy* **101**, 612–628 (2017).
9. Fedoseeva, S. & Zeidan, R. How (a)symmetric is the response of import demand to changes in its determinants? Evidence from European energy imports. *Energy Econ.* **69**, 379–394 (2018).
10. Grafström, J., Söderholm, P., Gawel, E., Lehmann, P. & Strunz, S. *Knowledge Accumulation from Public Renewable Energy R&D in the European Union: Converging or Diverging Trends?* (UFZ, 2017).
11. Strunz, S., Gawel, E., Lehmann, P. & Söderholm, P. Policy convergence as a multifaceted concept: the case of renewable energy policies in the European Union. *J. Public Policy* **37**, 1–27 (2017).
12. *Report on the Implementation of the Trade Policy Strategy Trade for All* (European Commission, 2017); http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0491&from=EN
13. Nemet, G. & Baker, E. Demand subsidies versus R&D: comparing the uncertain impacts of policy on a pre-commercial low-carbon energy technology. *Energy J.* **30**, 49–80 (2009).
14. Kim, K. & Kim, Y. Role of policy in innovation and international trade of renewable energy technology: empirical study of solar PV and wind power technology. *Renew. Sustain. Energy Rev.* **44**, 717–727 (2015).
15. Aïssa, M. S. B., Jebli, M. B. & Youssef, S. B. Output, renewable energy consumption and trade in Africa. *Energy Policy* **66**, 11–18 (2014).
16. Aubin, C. Accelerating Africa's energy transition. *Project Syndicate* (11 January 2018); https://www.project-syndicate.org/commentary/africa-renewables-solar-economic-incentives-by-charlotte-aubin-2018-01
17. *Global Energy & CO_2 Status Report 2017* (International Energy Agency, 2018); http://www.iea.org/publications/freepublications/publication/GECO2017.pdf
18. Victor, P. Questioning economic growth. *Nature* **468**, 370–371 (2010).
19. *The Millennium Development Goals Report 2015* (United Nations, 2015); http://www.undp.org/content/dam/undp/library/MDG/english/UNDP_MDG_Report_2015.pdf
20. Baldwin, R. The World Trade Organization and the future of multilateralism. *J. Econ. Perspect.* **30**, 95–116 (2016).
21. Mayer, K. *With the Stroke of a pen: Executive Orders and Presidential Power* (Princeton Univ Press, Princeton, 2002).
22. Celik, L., Karabay, B. & McLaren, J. When is it optimal to delegate: the theory of fast-track authority. *Am. Econ. J. Microecon.* **7**, 347–389 (2015).
23. Stern, N. *The Economics of Climate Change: The Stern Review* (Cambridge Univ. Press, Cambridge, 2006).
24. Tol, R. S. J. The structure of the climate debate. *Energy Policy* **104**, 431–438 (2017).
25. Ben Sita, B., Marrouch, W. & Abosedra, S. Short-run price and income elasticity of gasoline demand: evidence from Lebanon. *Energy Policy* **46**, 109–115 (2012).
26. Adewuyi, A. O. Determinants of import demand for non-renewable energy (petroleum) products: empirical evidence from Nigeria. *Energy Policy* **95**, 73–93 (2016).
27. Moore, A. Demand elasticity of oil in Barbados. *Energy Policy* **39**, 3515–3519 (2011).
28. Adeyemi, O. I., Broadstock, D. C., Chitnis, M., Hunt, L. C. & Judge, G. Asymmetric price responses and the underlying energy demand trend: are they substitutes or complements? Evidence from modelling OECD aggregate energy demand. *Energy Econ.* **32**, 1157–1164 (2010).
29. Wind, I. *HS Codes and the Renewable Energy Sector* (ICTSD, 2009); https://www.ictsd.org/downloads/2010/01/hs-codes-and-the-renewable-energy-sector.pdf

Author contributions
R.Z. outlined the theoretical background of the study. S.F. designed and performed the empirical analysis. Both authors wrote the manuscript.

Competing interests
The authors declare no competing interests.

Additional information
Supplementary information is available for this paper at https://doi.org/10.1038/s41893-018-0113-1.

Reprints and permissions information is available at www.nature.com/reprints.

Correspondence and requests for materials should be addressed to R.Z.

Publisher's note: Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.