Path Interdependence and Persistent Fossil Fuel Subsidies

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September 21, 2022

Abstract

Why do countries worldwide still heavily subsidize fossil fuels despite the accelerating threat of climate change? While most answers so far are exclusively about the domestic complications, I argue that the slow-paced phase-out of fossil fuel subsidies is partly caused by path interdependence, by which countries follow one another too often to move sluggishly, to do nothing, and even to roll back. Underpinning this contagious climate inaction is bounded rationality and risk aversion, with indecisive policy makers turning to their counterparts elsewhere when facing the high-stakes subsidy reform. In particular, this regressive policy emulation asserts more influence between the neighboring or linguistically proximate countries owing to the heuristics that bias people in searching and utilizing information from overseas. Using the data from 29 OECD countries over the past three decades on revising the gasoline tax—a direct measure to end the most common implicit subsidy regime for fossil fuels, spatial econometric analysis lends strong and robust support to my argument. Beyond climate and energy politics, my research also sheds light on the broad literature of diffusion and the political economy of subsidies in general.

Key words: Fossil fuel subsidies, Path interdependence, Policy emulation

Introduction

In the 2009 Pittsburgh Summit, the G20 leaders pledged to phase out inefficient fossil fuel subsidies as they "encourage wasteful consumption . . . and undermine efforts to deal with the threat of climate change" (G20 2009). The greenhouse gas emissions during the post-Pittsburgh decade were higher than in any previous one (IPCC 2022), yet those environmentally harmful subsidies are still massive among not only oil-rich dictatorships and emerging economies but also advanced democracies. In 2020, the world spent 6.8% of the global GDP to subsidize fossil fuels, and this astonishing number was even projected at 7.4% for 2025 (Parry, Black, and Vernon 2021). Such ironic contradiction between climate commitments and actions begs the following research question: why do countries worldwide still heavily subsidize fossil fuels?

Most previous answers to this question are about domestic politics exclusively.[1] Acknowledging a huge popular demand for affordable energy, many scholars highlight the political rationale that governments use fossil fuel subsidies as a redistributive instrument in exchange for votes or loyalty (Broz and Maliniak 2010; Cheon, Urpelainen, and Lackner 2013; Cheon, Lackner, and Urpelainen 2015; Finnegan 2021; Kim and Urpelainen 2016; see also Kyle 2018). Meanwhile, another strand of research pays attention to the well-entrenched fossil fuel interests, underscoring how path dependency or the tension between diffuse environmental benefits and concentrated economic costs enables the interest groups to retain those subsidies (Bechtel, Genovese, and Scheve 2019; Egli, Schmid, and Schmidt 2022; Inchauste and Victor 2017; Rickard 2022; Pierson 2000; Victor 2009).

In contrast to these existing studies, I argue that path interdependence undermines the reform of fossil fuel subsidies globally, with countries following one another too often to move sluggishly, to do nothing, or even to roll back. Behind this contagious climate inaction is bounded rationality and risk aversion, under which struggling policy makers facing the high-stakes subsidy reform turn to the decisions made by their foreign colleagues (Bennett 1991; Nicholson-Crotty 2009; Simon 1955). Considering the availability and representativeness heuristics that usually bias people in searching and utilizing information from overseas (Tversky and Kahneman 1974; Weyland 2005), I further develop the scope conditions that neighboring or linguistically proximate countries follow each other's moves more closely during the reform.

Subsidies are oftentimes implicit. When states undertax fossil fuels such that the negative externalities are not fully corrected, they actually subsidize people to stick with that socially and environmentally expensive energy (Coady et al. 2017; Parry et al. 2014; Parry, Black, and Vernon 2021; Whitley and van der Burg 2018). So raising taxes is a direct measure to remove the most

1. But see Mahdavi, Martinez-Alvarez, and Ross (2022) for an analysis on macro economic factors.

common subsidy regime for fossil fuels, which costs the G20 countries alone about $100 billion every year (exclusive of the E.U. and Saudi Arabia; OECD 2021). With that in mind, I operationalize the dependent variable for the empirical test by tracking the path of revising the excise tax on gasoline—the fossil fuel product that concerns most people on a daily basis.

Using the data from 29 OECD countries, 1990–2019, spatial econometric analysis lends strong and robust support to my argument. Specifically, it finds that the changing gasoline tax in one place is positively correlated to that elsewhere, with the magnitude of that mutual influence decaying as the geographic or linguistic closeness between two countries decreases. Such path interdependence is still present when the closeness is measured by common memberships in intergovernmental organizations (IGOs) or trade partnerships . These findings are substantively significant in explaining why the pace of the fossil fuel subsidy phase-out falls behind the growing urgency of climate change: at the equilibrium level, my estimation indicates that a stochastic shock that causes a single country to cut its gasoline tax by one unit could not only spread over third-fifth of its negative effect elsewhere, but also reinforce itself by four percent.

With "utmost concern that human activities have caused around 1.1 °C of warming to date," world leaders reaffirmed that they would phase out insufficient fossil fuel subsidies at COP26 in Glasgow (UNFCCC 2021). But the widespread tax cuts for fossil fuels amid high inflation in 2022 (Reuters 2022; Transport & Environment 2022), once again, showed how this pledge easily gave way to politics. While most previous studies pay exclusive attention to domestic factors, I add new to our understanding about the long-awaited subsidy phase-out of fossil fuel by showing that incrementalism, inactivity, and even regression are transnationally contagious throughout this endeavour. The negative spillover effect of such path interdependence is profound, given that governments worldwide already frequently yield to their very own political pressures to turn a blind eye to—and even expand—fossil fuel subsidies.

Beyond climate and energy politics, this research sheds new light on the scholarship of diffusion as well. By conventional wisdom, diffusion is believed to disseminate progressive norms and policies, such as democratization, economic liberalization, environmental protection, and rights promotion (see, to name a few, Gleditsch and Ward 2006; Greenhill, Mosley, and Prakash 2009;

Holzinger, Knill, and Sommerer 2008; Simmons and Elkins 2004). But overlooked by this vast body of research is the flip side of the coin (Gilardi and Wasserfallen 2019; Shipan and Volden 2021). Using the salient case of reforming fossil fuel subsidies, I extend the existing literature by concluding that norm and policy diffusion could be regressive as well, which hinders energy transition amid the growing threat of climate change. My contribution here also lies in shifting the research focus away from policy adoption while studying policy diffusion. Through demonstrating how issue definitions spread across different jurisdictions before actual policies do, Gilardi, Shipan, and Wüest (2021) remind us that diffusion could happen in several stages within a policy lifecycle. I echo this research agenda by showing the diffusion dynamics underpinning the overdue termination of a detrimental policy, *i.e.,* subsidizing fossil fuels.

The Politics of Fossil Fuel Subsidies

Acknowledging a huge public demand for affordable energy, many scholars highlight the political rationale that governments use fossil fuel subsidies as a readily available redistributive instrument in exchange for electoral support or regime loyalty. For instance, Cheon, Urpelainen, and Lackner (2013) suggest that limited state capacity leads to more of these expenses because the government is unable to easily buy votes otherwise through some more targeted redistribution programs. Nevertheless, Cheon, Lackner, and Urpelainen (2015) further discover that countries with capable bureaucracies also subsidize fossil fuels considerably by using state-owned enterprises to insulate consumers from volatile oil prices. Broz and Maliniak (2010) argue that malapportionment incentivizes governments to favour fuel-reliant rural constituents by undertaxing gasoline, and Kim and Urpelainen (2016) find the similar rural bias in autocracies. Finnegan (2021) underscores the importance of the ever-changing political competition, showing that the prospect of reforming fossil fuel subsidies depends on the extent to which politicians are electorally secure to pursue a long-term objective (*e.g.,* carbon neutrality) at the short-term cost of voters (*e.g.,* rising living costs).

Once a subsidy policy is in place, people tend to take that for granted, so it is increasingly challenging for governments to phase fossil fuel subsidies out as time goes on (Victor 2009). Acemoglu and Robinson (2001, p. 649) formally argue that "when political institutions cannot credibly commit to future policy," inefficient redistribution, like energy subsidies, becomes the tool for governments to stay in power. The long overdue subsidy reform in Nigeria is one of the good cases to illustrate the political delicacy of the matter. The Nigerian government instituted petrol subsidies as a temporary measure for only six months four decades ago; yet after repeated, unsuccessful attempts to remove these subsidies and the following violence, they are now paradoxically a massive fiscal burden for the Africa's largest oil producer but also "the lifeblood of politicians" (The Economist 2020; Onyeiwu 2021).

Meanwhile, another strand of research pays attention to the well-entrenched fossil fuel interests. The interest groups that benefit from fossil fuel subsidies are well organized and moreover, the nonstop provision of government relief continuously reinforces the political power they have to retain their vested interests (Inchauste and Victor 2017; Pierson 2000; Victor 2009). Beyond this path dependency, the frequently seen tension between diffuse environmental benefits and concentrated economic costs consolidates fossil fuel interests as well. In this regard, Bechtel, Genovese, and Scheve (2019) find that the workers from carbon-intensive industries are united in opposing actions on climate change (see also Gaikwad, Genovese, and Tingley, FirstView). This finding implies the interest groups' ability to mobilize local but powerful resistance against the reform of fossil fuel subsidies. In addition, Rickard (2022) argues that geographic concentration enables the beneficiaries of environmentally damaging subsidies to enjoy more political influence than do environmentalists, and the former's veto power becomes even greater under plurality electoral systems (see also Egli, Schmid, and Schmidt 2022).

Path Interdependence

A Behavioral Explanation

As discussed above, various domestic constraints make the fossil fuel subsidy phase-out, if any, back-and-forth in almost every country. Among the reform cases in 28 countries reviewed by the IMF in 2013, for instance, 16 of them ended up with the reintroduction of subsidies or the reversal of pro-reform policies (Whitley and van der Burg 2015). From 2015 to 2019, according to BloombergNEF (2021), only six among the G20 members were in the "right direction" of reforming fossil fuel subsidies, while the remaining majority either had mixed progress at best or even expanded funding support for fossil fuels. That the US government did nothing on the country's gasoline tax since 1993 is another example here. As the real tax rate depreciates with inflation, this tax freeze in fact increasingly subsidizes the consumption of fossil fuels as time goes on. To make matters worse, the impact of incrementalism, inactivity, and regression throughout the fossil fuel subsidy reform is not isolated due to path interdependence, by which governments rarely ever act independently but instead follow one another's moves too often. In the following, I develop a behavioral explanation underpinning this interplay that severely delays the global energy transition.

People dislike welfare retrenchment like a subsidy phase-out (*e.g.,* Lee et al. 2020). And due to the well-documented negativity bias, voters are more likely to punish governments for the removal of subsidies than rewarding them for some subsequent remedies, if any (Kernell 1977; Soroka 2006). So, governments have to carefully deal with the intense popular opposition to the reform of fossil fuel subsidies, as demonstrably shown by the destructive mass protests in Britain 2000, France 2018, and Ecuador 2019, just to name a few. Kim and Yang (2022) and McCulloch et al. (2021) provide the systematic evidence about this matter's political delicacy by linking the rising pump price to the declining support for the incumbent. Facing such politically charged issue with high-stakes as subsidy reform, struggling policy makers oftentimes turn to their foreign counterparts to "reduce the complex tasks of assessing probabilities and predicting values to simpler judgmental operations" (Tversky and Kahneman 1974, p. 1124; see also Walker 1969). Put simply, policy choices elsewhere "change[] the information set on which governments base their own policy decisions" (Simmons and Elkins 2004; see also Brooks 2005; Swank 2006). Bennett (1991, p. 220) conceptualizes that as policy imitation (or emulation), by which political elites "see how other states [respond] to similar political pressures . . . and to bring foreign [experience] to bear within domestic policy-making processes."

Behind policy emulation is bounded rationality: people usually tend to adopt simple analysis with limited information to make seemingly satisfactory, instead of optimal, decisions due to cognitive and contextual limitations (Jones 1999; Simon 1955; Weyland 2007). That is to say, it is rational for decision makers to use cues, such as someone else's decisions, as shortcuts in choosing alternatives in order to save expensive cognitive resources and time (Jones 1999). Extensive research finds such cue-taking prevailing in elite decision-making environments like parliaments, where inexperienced legislators follow some of their colleagues to vote (for one of the latest research, see Fong 2020). In the cross-national context of reforming fossil fuel subsidies, similarly, risk-averse policy makers are prone to take the policy choices made somewhere else as a guidance to their next moves for the assurance that the path forward is not political turmoil. These cues also constitute the "social construction of appropriate behavior," where policy makers benchmark themselves against others for conformity (Lee and Strang 2006, p. 889; Holzinger, Knill, and Sommerer 2008). When the reform is sluggish in most nations, which is the *status quo*, policy makers in no single nation have enough assurance or peer pressure to make the first move to speed up. So, the progress to phase out fossil fuel subsidies remains slow globally.

The more urgent is a problem, as Bennett (1991, p. 223) notes, "the more likely will be the imitation of solutions without lengthy analysis and investigation" (see also Lesch and Millar 2022). A similar observation is made by Nicholson-Crotty (2009) too, who finds that rational policy makers tend to forgo information gathering and learning in favor of immediately adopting the readily available solutions from elsewhere when facing salient policy issues that concern a great many people. For these reasons, policy emulation particularly prevails throughout the reform of fossil fuel subsidies, which always demands urgent political decisions owing to the rapidly changing situations and has greatest salience for the general public because of its substantial impact on everyone's pocketbook. In addition, behavioral economics reports that even the most experienced elites are not immune from becoming more risk-averse when the stakes are high (*e.g.,* Pope and Schweitzer 2011). While making decisions on fossil fuel subsidies, policy makers could feel less politically risky by just sticking with the actions taken by their counterparts overseas. With everyone's action being dependent on everyone else's, such risk aversion could perpetuate incrementalism and inaction in phasing out fossil fuel subsidies everywhere.

Scope Conditions

By policy emulation, policy makers are biased by two heuristics that "skew people's attention and shape their evaluation" (Tversky and Kahneman 1974; Weyland 2005, p. 284). Accordingly, my argument is subject to the scope conditions that are in the spirit of the first law of geography (Tobler 1970): every country follows each other in reforming fossil fuel subsidies, but near countries follow each other more closely than do distant pairs. Under the influence of the availability heuristic, policy makers tend to pay more attention to the countries that are "noticeable and close at hand" (Shipan and Volden 2021, p. 40). Such information sources as neighboring countries always occur to people first, and they may then squeeze out the alternatives by making people's limited cognitive capacity saturated. Meanwhile, common language could constitute the noticeability here too as "[i]f decision makers know one thing about another country, it is usually the language its citizens speak"(Simmons and Elkins 2004). Collecting and processing policy information from neighboring or linguistically proximate countries also involves much less time and cognitive resources thanks to the predisposed familiarity of the context and frequent, extensive transnational communications (Holzinger and Knill 2005). So, policy makers may overlook the information from other places intentionally due to time pressure or unwittingly under the influence of cognitive laziness. Considering the source noticeability and information accessibility together, the British elites, for instance, may halt information searching after knowing the state of affairs in the other side of the pond, as well as continental Europe, whereas pay little notice to, say, the remote Japan and Korea.

Joining this availability heuristic is the representativeness heuristic, which "induces people to draw excessively clear, confident, and firm inferences from a precarious base of data" (Tversky and Kahneman 1974; Weyland 2005, p. 284; see also Stolwijk and Vis 2021). Even with complete information, this cognitive bias misleads policy makers to take the cues from near countries disproportionately while undervaluing the others from the rest of the world. Neighboring or linguistically proximate countries are necessarily analogue to each other in various ways, and policy makers tend to use the similarity as a proxy for the relevance of foreign experience to domestic decision making (Walker 1969). In addition, political elites, like all people, are innately inclined to prefer the information sources they feel familiar or connected with, which is an unconscious in-group bias (Bricker and LaCombe 2021; Dragojlovic 2013). At the macro level, that norm cascade and policy learning overwhelmingly occur within regions or between "peer" countries is indicative of this source cue effect (Brooks 2005; Cao 2009; Simmons and Elkins 2004). Moreover, some recent survey studies find politicians indeed revealing more willingness to learn from whom they feel closer to (Butler et al. 2017; Einstein, Glick, and Palmer 2019; Pereira 2022), lending micro-level support to the representativeness bias.

Research Design

Dependent Variable

Fossil fuel subsidies exist in various forms around the globe. Oil-rich countries in some instances make the so-called induced transfers to consumers by lowering fuel prices even below production costs. This pricing intervention allows scholars to compare the retail price of, say, gasoline against an international benchmark price to estimate the extent of subsidies (Cheon, Urpelainen, and Lackner 2013; Fails 2019; Mahdavi, Martinez-Alvarez, and Ross 2022; Ross, Hazlett, and Mahdavi 2017). In some oil-importing developing nations, in comparison, the governments make direct budgetary transfers to consumers. Yet fossil fuel subsidies oftentimes are more implicit.[2] When states undertax fossil fuels such that the negative externalities are not fully corrected, for example, they actually subsidize people to stick with that socially and environmentally expensive energy (Coady et al. 2017; Parry et al. 2014; Parry, Black, and Vernon 2021; Whitley and van der Burg 2018). From the perspective of government account, undertaxing fits the second definition of subsidy in the Agreement on Subsidies and Countervailing Measures as "government revenue that is otherwise due is foregone or not collected" (WTO 1994, p. 229). So the OECD directly uses the term tax expenditures in referring to the implicit fossil fuel subsidies of this kind, which costs the G20 countries about $100 billion each year (exclusive of the E.U. and Saudi Arabia; OECD 2021). Furthermore, the annual deadweight loss caused by underpricing gasoline and diesel alone is estimated at $92 billion (Davis 2014).

2. See Koplow (2018) for a discussion about the types of fossil fuel subsidies and the existing methods to estimate them.

The estimates for the induced and direct budgetary transfers are subject to vastly different methods of calculation. In contrast, raising taxes is a direct measure of reforming the most common implicit subsidy regime for fossil fuels. With that in mind, and after taking data availability into consideration, I operationalize my dependent variable by tracking the path of revising the tax on gasoline—the fossil fuel product that concerns most people on a daily basis. The gasoline tax data is from the OECD Energy Prices and Taxes Quarterly, an exclusive compilation by the International Energy Agency (IEA).[3] Upon taking care of missing values, I have a balanced panel dataset consisted of 29 OECD nations, 1990–2019 (see Figure 1). As discussed previously, developed nations undertax—or implicitly subsidize—gasoline considerably too, so the limited sample would only have a minimal ceiling effect on my empirical results. By tax, I consider the *ad valorem* excise duty only, *i.e.*, excluding the value-added tax, because otherwise it would artificially fluctuate with volatile oil prices (Finnegan 2021). It generally takes some time for a tax proposal to become effective, so a tax raise in the current year could reflect some prior efforts in reforming fossil fuel subsidies as well. I apply a three-year moving average to my dependent variable to take this delayed effect into account.

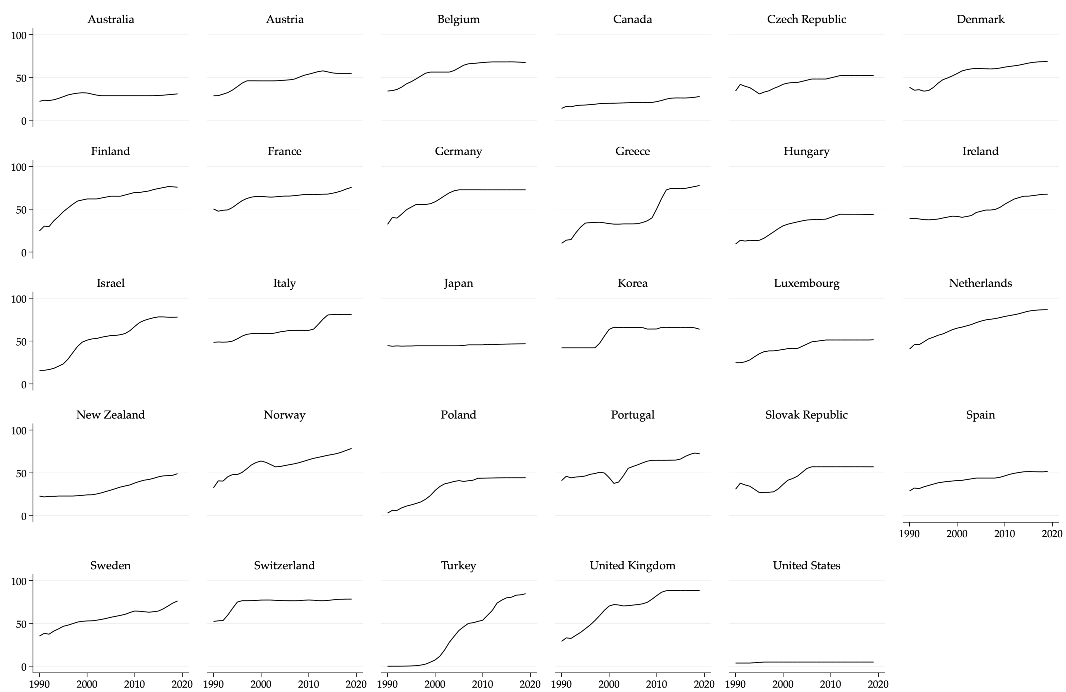
Modelling Interdependence

I carry out quantitative analysis with the spatial lag regression model. It is suitable for testing my argument about path interdependence by allowing me to examine how countries respond to each other's changing gasoline tax all together in proportion to their closeness by geography or language. For a single country i in a given year t, the spatial lag takes $\sum_j w_{i,j,t} \times y_{j,t}$, in which j indexes every country other than i, w denotes the spatial weights that quantify the closeness between two countries , and y is the dependent variable. In words, it is a weighted average of the gasoline taxes elsewhere, with the weights accounting that near countries mutually influence one another more than do distant countries.

I use the binary coding for the two spatial lags derived from the scope conditions of my argument: $w_{i,j,t} = 1$ if i and j neighbor or are linguistically proximate to each other. Specifically, two countries are considered neighbors if they border by land or the sea less than 400 miles wide

3. https://www.iea.org/data-and-statistics/data-product/oecd-energy-prices-and-taxes-quarterly (by subscription).

Figure 1: The Slow-Moving Excise Tax on Gasoline in OECD Countries, 1990–2019



US cent (constant as of 2015) per liter; OECD Energy Prices and Taxes Quarterly, IEA.

(The Correlates of War Project 2017; Douglas et al. 2002). Meanwhile, the linguistic proximity is determined by whether two countries share any *de facto* or *de jure* official language based on the detailed converge of more than 6,500 languages in the world (Gurevich et al. 2021). Yet focusing on either geography or language alone might not be sufficient to fully capture the influence of the availability and representativeness heuristics on policy emulation. Britain, for example, not only neighbors a part of Europe but also deeply connects to its English-speaking "peers" scattered in other continents. Its policies consequently comprise the impacts from these two clusters of information sources together. So next to the two single-sourced spatial lags, I also have a composite spatial lag wherein the weights equal one if two countries either border to or share a common language with the other. Though countries only have a limited number of geographic and linguistic neighbors as defined by the spatial weights, the construction of the spatial lag model actually enables them to neighbor—and thus influence—many more in the end by higher-order contiguity. This feature perfectly connects to my argument that even a single country could have a global negative impact on the reform of fossil fuel subsidies through path interdependence.

Fixed Effects and Monadic Variables

Some country-specific heterogeneities, such as institutions or geographies, make the gasoline tax structurally lower in some places than anywhere else. But my argument only concerns its direction and magnitude of change in each country. To substantiate this "change" (compared to "levels") argument, I include the country fixed effects to my regression model, which also guard my results from unobserved spatial clustering (Plümper, Troeger, and Manow 2005; Plümper and Neumayer 2010). Sometimes governments are likely to change the gasoline tax one after another amid common shocks, such as oil price spikes or international summits (Bakaki and Bernauer 2017), within a short time window. Ignoring external shocks like these might compromise my empirical test due to spurious interdependence, which is merely driven by each individual country's independent yet coincidental policy response to a global event. Considering this "common exposure" problem, I incorporate the year fixed effects in the model too (Plümper and Neumayer 2010).

Several domestic political or economic factors may have an impact on the reform of fossil fuel subsidies, and I add them to the regression as independent variables. In light of the rural bias of underpricing road fuels (Broz and Maliniak 2010; Kim and Urpelainen 2016), I include urban population in percentage of the total. I then include a binary indicator that equals one if a country is during an election cycle, given the political business cycle of fuel taxes discussed in Finnegan (2021). In spite of various external constraints, the willingness of political elites themselves matters for the successful phase-out of fossil fuel subsidies too. Since the left is generally pro-reform and in favor of climate action, I use the seat share of leftists in government as a proxy measure for the "willingness to phase out," with the data from Armingeon, Engler, and Leemann (2021). The research by Abou-Chadi and Kayser (2017) implies that politicians are more reluctant to pursue environmentally sound reforms during economic downturns, so I include GDP growth and unemployment rate to take this tension into consideration. Joining these two variables is GDP per capita, accounting the claim that the salience of environmental protection increases with the growing average wealth after a tipping point (Grossman and Krueger 1995).[4] Last, in respect of Mahdavi, Martinez-Alvarez, and Ross (2022)'s conclusion that fuel taxes are determined by slow-moving economic factors like income and fossil fuel wealth, I add a nation's petroleum rents and government debt (both normalized by GDP) to my model.[5]

Findings

Table 1 presents the main regression results. The first column includes all variables but the spatial lag itself to serve as a baseline. The three following columns correspond to the model with the spatial lag by geographic contiguity, linguistic proximity, and both, respectively. The positively signed, statistically significant coefficient estimates of them indicate that the changing gasoline tax in a country is positively correlated with that elsewhere, corroborating my argument about path interdependence. At face value, for example, the long stagnation of the gasoline tax in the US leads the country's neighbors or English-speaking "peers" like Canada and the UK to less likely to keep their pace of raising the gasoline duty with the need to fight climate change either. At the same time, conversely, these countries undermines the prospect of raising the gasoline tax in the US by passing their very own incrementalism. Besides, comparing the last three columns against

4. I do not include the squared term as the countries in my sample, developed economies, are already beyond that tipping point.

5. Unless specified, these variables are from the World Bank's World Develop Indicators. See Table A1 in the Appendix for summary statistics.

the first, the considerably improved model fit (indicated by the shrinking Bayesian information criterion, or BIC) is noteworthy, which implies the substantial explanatory power—and substantive significance—of path interdependence in explaining the laggard fossil fuel subsidy reform worldwide.

Table 1: Path Interdependence of the Slow-Moving Gasoline Tax, OECD Countries, 1990–2019

	Baseline	Geo. Contiguity	Comm. Language	Composite
Spatial Lag		0.467^{***}	0.417^{***}	0.397^{***}
		(0.025)	(0.031)	(0.030)
Urban Pop.	0.357^{**}	0.401^{***}	0.319^{***}	0.362^{***}
	(0.115)	(0.094)	(0.102)	(0.100)
Left Seats in Gov.	0.008	0.013^{*}	0.012^{*}	0.011^{*}
	(0.007)	(0.006)	(0.006)	(0.006)
Election Year	0.176	0.131	0.176	0.139
	(0.534)	(0.435)	(0.472)	(0.462)
GDP per capita	-0.091	-0.075	-0.044	-0.018
	(0.077)	(0.063)	(0.068)	(0.067)
GDP Growth	-0.209^{*}	-0.244^{**}	-0.195^{*}	-0.253^{**}
	(0.110)	(0.090)	(0.097)	(0.095)
Unemployment	0.373^{***}	0.183^{*}	0.221^{*}	0.268^{**}
	(0.107)	(0.088)	(0.096)	(0.093)
Inflation	-0.464^{***}	-0.399^{***}	-0.404^{***}	-0.416^{***}
	(0.034)	(0.028)	(0.030)	(0.029)
Petro Rents	0.883	0.527	0.645	0.544
	(0.548)	(0.448)	(0.485)	(0.476)
Gov. Debt	-0.008	-0.012	-0.004	-0.005
	(0.016)	(0.013)	(0.014)	(0.014)
Log likelihood	-2841.111	-2735.062	-2784.906	-2768.826
BIC	5946.194	5544.577	5644.265	5612.106
N	870	870	870	870

Standard errors in parentheses; $^{*}p < 0.050$, $^{**}p < 0.010$, $^{***}p < 0.001$ (one-sided).

The coefficient estimates of spatial lags shown in Table 1 confine the interpretation to the direct contiguity, yet the impact of path interdependence reverberates through high-order neighbors. Portugal, for instance, immediately neighbors and influences Spain alone, but it then neighbors and influences—though at the decaying magnitude—to Spain's neighbors France and Italy, and so forth. This indefinite expansion means that even a single country could have a global negative spillover effect on the phase-out of fossil fuel subsidies. In addition, countries even become contiguous with—so have an influence on—themselves starting from the second-order contiguity.

Consider the Portugal-Spain case again: upon being absorbed by Spain, a part of the effect from Portugal bounces back to its origin as the contiguity runs both ways. In other words, Portugal receives a part of the effect that originates from itself through the neighboring Spain. The sluggish fossil fuel subsidy reform in each country is thus self-perpetuating owing to the so-called feedback loop like that.

Following Gleditsch and Ward (2008), LeSage and Pace (2009), and Whitten, Williams, and Wimpy (2021), among others, Table 2 uses the composite spatial lag (column 4, Table 1) to decompose the convoluted effects of path interdependence. Consider a stochastic shock that causes a country to cut its gasoline tax by one unit, as the first row depicts. At the first order, the country's neighbors follow this regressive move and lower their taxes by almost 0.4 in total—the effect size plainly quantified by the spatial lag coefficient. At the same time, such negative spillover effect reaches to the country's second-order neighbors, indirectly influencing more nations but at the geometrically decreasing magnitude. Also, this country's gasoline tax cut reinforces itself by more than 0.03 due to the effect bouncing back within the feedback loop. These effects reverberate infinitely while accumulating to the equilibrium level, as shown by the last row. In sum, that backward move during the fossil fuel subsidy reform not only spreads over third-fifth of its negative effect elsewhere but also reinforce itself by four percent due to path interdependence.

Table 2: The Decomposed Effects of Path Interdependence

Order	Direct	Spillover	Total
Zero	1.000	0.000	1.000
	(1.000, 1.000)	(0.000, 0.000)	(1.000, 1.000)
First	0.000	0.397	0.397
	(0.000, 0.000)	(0.347, 0.447)	(0.347, 0.447)
Second	0.036	0.121	0.157
	(0.027, 0.046)	(0.093, 0.154)	(0.120, 0.199)
Third	0.003	0.059	0.062
	(0.002, 0.004)	(0.040, 0.085)	(0.042, 0.089)
Equilibrium	1.044	0.614	1.658
	(1.032, 1.058)	(0.498, 0.749)	(1.530, 1.807)

90% confidence intervals based on 1,000 simulations in parentheses.

The results presented so far are robust to different empirical specifications as shown with more details by Table A2—6 in the Appendix. In summary, I rerun my main regression model with the spatial weights not row-standardized, the year fixed effects excluded, the temporal and cross-sectional robust standard errors, and the first-differenced dependent variable.

Last, in addition to geographic contiguity and linguistic proximity, I also operationalize the closeness between countries with two more indicators: common IGO memberships and trade partnerships (see the Appendix for technical details). IGOs by design are where countries communicate with and learn from each other extensively (Cao 2009; Holzinger and Knill 2005; Holzinger, Knill, and Sommerer 2008; Simmons and Elkins 2004; Ward and Cao 2012). Besides, given each IGO representing a certain agenda or values, two countries having more common memberships indicates an *ex ante* preference similarity. Conversely, staying in the same IGO could push the fellow countries to become even closer (Chelotti, Dasandi, and Jankin Mikhaylov 2022; Egel and Obermeier, Accepted). Like the expansion of IGOs, the exponentially growing international trade is one of the most noticeable features in the globalized world. Meanwhile, trade knits an elite network that disseminates information transnationally, and brings policy makers in different countries who would be otherwise distant much closer to each other (Simmons and Elkins 2004). In conclusion, while following others in reforming fossil fuel subsides, countries could follow their most connected "fellows" in IGOs and their top trade partners more closely. As Table A7–8 shows, the statistical results in support of path interdependence remain unchanged despite the alternative spatial lags. It shows that my argument is robust to the differently formulated scope conditions.

Conclusion

Why do countries worldwide still heavily subsidize fossil fuels despite the pledges to phase them out time and time again? In addition to the environmental implications, this research question's scholarly and policy significance is also due to the adverse distributional effect of fossil fuel subsidies: these expenditures benefit the well-off disproportionately than the people in need, and crowd out the fiscal resources that would otherwise be spent more efficiently (*e.g.,* Del Granado, Coady, and Gillingham 2012). Notwithstanding the proven effectiveness in reducing greenhouse gas emissions and fiscal imbalance, political scientists find the fossil fuel subsidy reform a politically delicate policy for governments (Broz and Maliniak 2010; Cheon, Urpelainen, and Lackner 2013; Cheon, Lackner, and Urpelainen 2015; Finnegan 2021; Kim and Urpelainen 2016; Victor 2009). Compared to the existing literature that focuses on domestic politics exclusively, I add new to our understanding of the matter by considering the interdependent policy making. Specifically, I argue that the slow-paced phase-out of fossil fuel subsidies is partly caused by path interdependence, by which countries follow one another too often to move sluggishly, to do nothing, and even to roll back. Behind this contagious climate inaction is bounded rationality and risk aversion, with indecisive policy makers turning to their counterparts elsewhere when facing the high-stakes subsidy reform. Using data on the changing gasoline tax in 29 OECD countries over the past three decades, spatial econometric analysis lends strong and robust support to my argument.

My research contributes to the broad literature of diffusion in two ways. While conventional wisdom finds that various diffusion mechanisms disseminate progressive norms and policy innovations around the globe (Gleditsch and Ward 2006; Greenhill, Mosley, and Prakash 2009; Holzinger, Knill, and Sommerer 2008; Simmons and Elkins 2004), I theorize and substantiate the flip side of the coin. Using the salient case of reforming fossil fuel subsidies, I conclude that norm and policy diffusion could become regressive as well (Gilardi and Wasserfallen 2019; Shipan and Volden 2021), which hinders energy transition amid the growing threat of climate change. By arguing and showing the diffusion dynamics underpinning the overdue termination of a detrimental policy, *i.e.,* subsidizing fossil fuels, my second contribution lies in shifting the research focus away from policy adoption while studying policy diffusion. Doing so echos the research agenda advocated by Gilardi, Shipan, and Wüest (2021), which reminds scholars that diffusion could happen in each and every stage of a policy lifecycle.

In this article, I primarily analyze the fossil fuel subsidies for consumers without an enough engagement with those for producers. Generally, the latter is even more opaque. Yet with some newly available data sources, such as Bailout Watch, Energy Policy Tracker, and Fossil Fuel Subsidy Tracker, researchers in the future may consider to pursue the interdependent government support for fossil fuel and related companies. Given its trade implications, such topic deserves special attention from international political economists (Steenblik, Sauvage, and Timiliotis 2018;

Ward and Cao 2012). With intense popular opposition and entrenched interest groups, the case of fossil fuel subsidies is representative of the political delicacy of reforming unsustainable subsidies—environmentally, fiscally, or both—in general. And it is worth seeing whether my argument about path interdependence might be generalized to other cases, such as the subsidy reforms aiming at the fishing, farming, or extractive industries (Rickard 2022).

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Appendix

Summary Statistics

Table A1 shows summary statistics for the variables used in Table 1 in the main text.

Table A1

	Minimum	Mean	Maximum	Standard Deviation
Gasoline Tax	0.03	48.49	88.60	20.02
S-Lag, geo. Contiguity	0.00	47.20	84.69	21.80
S-Lag, Comm. Language	0.00	41.27	84.69	19.77
S-Lag, Composite	0.03	48.36	84.69	13.91
Urban Pop.	47.91	76.24	98.04	10.74
Left Seats in Gov.	0.00	35.05	100.00	36.00
Election Year	0.00	0.26	1.00	0.44
GDP per capita	4.74	35.74	105.45	19.93
GDP Growth	−11.61	2.50	25.18	2.88
Unemployment	0.50	7.74	27.50	3.95
Inflation	−5.21	4.31	143.64	10.34
Petro Rents	0.00	0.36	10.95	1.20
Gov. Debt	4.64	72.89	222.88	36.03

Spatial Weights Not Row-Normalized

I follow the econometric convention to row-standardize the spatial weights for the main results, making my spatial lag coefficients more comparable to one another. Yet doing so assumes the "homogeneous exposure," which means that the total influence countries receive from others are constant regardless different countries having differing numbers of neighbors (Neumayer and Plümper 2016). Here, I relax this assumption, and find the statistical results qualitatively unchanged (Table A2).

Different Standard Errors

That random errors of regression model are correlated would compromise my statistical inference by underestimating the uncertainty. To address this concern, I replicate my main model with different standard errors, and find the spatial lags still statistically significant. Since the only possible changing part here compared to the main results here is the uncertainty estimates (while the

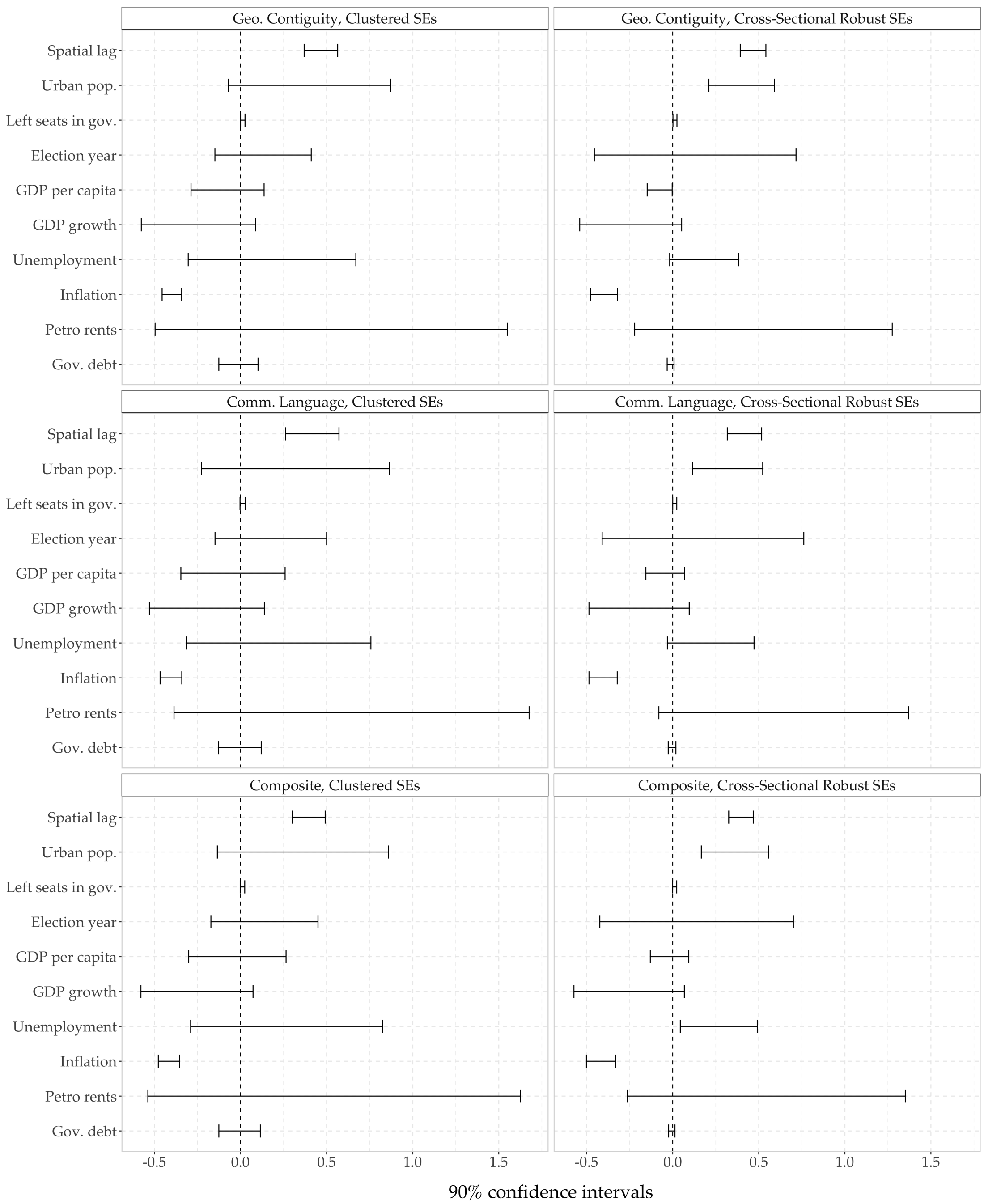
Table A2

	Geo. Contiguity	Comm. Language	Composite
Urban Pop.	0.328***	0.331**	0.302**
	(0.099)	(0.122)	(0.109)
Left Seats in Gov.	0.011*	0.009	0.009
	(0.006)	(0.007)	(0.007)
Election Year	0.118	0.193	0.189
	(0.458)	(0.513)	(0.498)
GDP per capita	−0.064	−0.081	−0.067
	(0.066)	(0.074)	(0.072)
GDP Growth	−0.231**	−0.209*	−0.213*
	(0.094)	(0.106)	(0.103)
Unemployment	0.277**	0.334***	0.309**
	(0.092)	(0.106)	(0.101)
Inflation	−0.458***	−0.451***	−0.448***
	(0.029)	(0.033)	(0.031)
Petro Rents	0.391	0.867	0.738
	(0.472)	(0.527)	(0.513)
Gov. Debt	−0.001	−0.009	−0.008
	(0.014)	(0.016)	(0.015)
Spatial Lag	0.715***	0.300*	0.492***
	(0.046)	(0.132)	(0.084)
Log likelihood	−2796.267	−2830.906	−2824.135
BIC	5666.987	5736.266	5722.723
N	870	870	870

Standard errors in parentheses; $^{*}p < 0.050$, $^{**}p < 0.010$, $^{***}p < 0.001$ (one-sided).

point estimates and model statistics are invariable under different standard errors), I use the error bars to visualize the updated confidence intervals around the estimated coefficients in Figure A1. Specifically, the clustered (at the country level) standard errors are robust to the temporal correlation of random errors. And the cross-sectional robust stand errors are made possible through the method developed by Driscoll and Kraay (1998).

Figure A1: Uncertainty Estimates by Different Standard Errors



Year Fixed Effects Excluded

There is no consensus in what is the correct way of controlling temporal effects for panel data alike. With regard to spatial regression in particular, Franzese and Hays (2008) and Plümper and Neumayer (2010) warn applied researchers of the pitfall of the year fixed effects. So in this part, I remove them from my model but include oil price—the primary temporal factor that affects the changing gasoline tax in different countries at the same time—instead, and find the statistical results remain the same qualitatively under this less restrictive specification (Table A3).

Table A3

	Geo. Contiguity	Comm. Language	Composite
Urban Pop.	0.462***	0.663***	0.485***
	(0.096)	(0.099)	(0.101)
Left Seats in Gov.	0.015**	0.018**	0.014**
	(0.006)	(0.006)	(0.006)
Election Year	0.024	0.071	0.084
	(0.444)	(0.459)	(0.466)
GDP per capita	0.316***	0.286***	0.313***
	(0.049)	(0.052)	(0.052)
GDP Growth	−0.129*	−0.124	−0.152*
	(0.077)	(0.079)	(0.081)
Unemployment	0.071	0.067	0.164*
	(0.085)	(0.088)	(0.089)
Inflation	−0.439***	−0.435***	−0.451***
	(0.027)	(0.028)	(0.029)
Petro Rents	−0.228	0.154	0.009
	(0.444)	(0.459)	(0.466)
Gov. Debt	0.028**	0.060***	0.034**
	(0.012)	(0.012)	(0.013)
Oil Price	0.033***	0.026**	0.023**
	(0.009)	(0.009)	(0.009)
Spatial Lag	0.508***	0.521***	0.517***
	(0.022)	(0.024)	(0.025)
Log likelihood	−2772.246	−2785.533	−2803.020
BIC	5625.714	5652.288	5687.262
N	870	870	870

Standard errors in parentheses; $^{*}p < 0.050$, $^{**}p < 0.010$, $^{***}p < 0.001$ (one-sided).

Dependent Variable First-Differenced

The gasoline tax has some "memory" due to the incrementalism in fiscal policy-making: the tax rate in a country is correlated with the past values of itself. Here, I apply first-difference to my dependent variable to remove its temporal correlation (up to the first order). Theoretically, using the first-differenced dependent variable along with the country fixed effects tests a slightly different variant of my argument: the changing pace at which countries revise the gasoline tax is interdependent. As shown by Table A4 (specification following the last subsection's), I find that the statistical results in support of path interdependence still hold.

Table A4

	Geo. Contiguity	Comm. Language	Composite
Urban Pop.	0.036	0.032	0.036
	(0.031)	(0.031)	(0.031)
Left Seats in Gov.	0.002	0.002	0.002
	(0.002)	(0.002)	(0.002)
Election Year	0.051	0.045	0.047
	(0.139)	(0.139)	(0.139)
GDP per capita	-0.049^{***}	-0.049^{***}	-0.051^{***}
	(0.015)	(0.015)	(0.015)
GDP Growth	-0.068^{**}	-0.071^{**}	-0.070^{**}
	(0.024)	(0.025)	(0.024)
Unemployment	0.118^{***}	0.123^{***}	0.120^{***}
	(0.027)	(0.027)	(0.027)
Inflation	-0.022^{**}	-0.023^{**}	-0.022^{**}
	(0.008)	(0.008)	(0.008)
Petro Rents	-0.222	-0.211	-0.225
	(0.137)	(0.138)	(0.137)
Gov. Debt	-0.013^{***}	-0.013^{***}	-0.013^{***}
	(0.004)	(0.004)	(0.004)
Oil Price	-0.001	-0.002	-0.001
	(0.003)	(0.003)	(0.003)
Spatial Lag	0.118^{**}	0.097^{*}	0.095^{*}
	(0.038)	(0.046)	(0.044)
Log likelihood	-1644.056	-1646.490	-1646.362
BIC	3368.927	3373.796	3373.538
N	841	841	841

Standard errors in parentheses; $^{*}p < 0.050$, $^{**}p < 0.010$, $^{***}p < 0.001$ (one-sided).

Spatial Lag by Common IGO Memberships

As discussed theoretically in the main text, the spatial lag in this part is based on common IGO memberships. With that data from Pevehouse et al. (2020), I use k-nearest neighbors (KNN) to define the new binary spatial weights (Gleditsch and Ward 2008; Zhukov and Stewart 2013): $w_{i,j,t} = 1$ if j is among the top four ($k = 4$) or seven ($k = 7$) countries that have most common IGO memberships with i. Replicating my main regression model with these two new spatial lags lends equal support to my argument about path interdependence (Table A5).

Table A5

	IGO, KNN ($k = 4$)	IGO, KNN ($k = 7$)
Urban Pop.	0.365^{***}	0.338^{**}
	(0.110)	(0.110)
Left Seats in Gov.	0.008	0.008
	(0.007)	(0.007)
Election Year	0.148	0.145
	(0.507)	(0.507)
GDP per capita	−0.103	−0.072
	(0.073)	(0.074)
GDP Growth	-0.238^{*}	-0.218^{*}
	(0.105)	(0.104)
Unemployment	0.354^{***}	0.369^{***}
	(0.102)	(0.102)
Inflation	-0.466^{***}	-0.471^{***}
	(0.032)	(0.032)
Petro Rents	0.777	0.818
	(0.521)	(0.521)
Gov. Debt	−0.003	−0.006
	(0.015)	(0.015)
Spatial Lag	0.219^{***}	0.282^{***}
	(0.068)	(0.084)
Log likelihood	−2836.178	−2836.763
BIC	5746.810	5747.979
N	870	870

Standard errors in parentheses; $^{*}p < 0.050$, $^{**}p < 0.010$, $^{***}p < 0.001$ (one-sided).

Spatial Lag by Trade Partners

Finally, I replace the spatial lag by the one based on trade partnerships as reasoned in the main text. Using the data from Barbieri, Keshk, and Pollins (2009), I use the KNN rule again to define the binary weights: $w_{i,j,t} = 1$ if j is among the top four ($k = 4$) or seven ($k = 7$) trade partners of i by bilateral trade flows. The results in support of path interdependence still hold (Table A6).

Table A6

	Trade, KNN ($k = 4$)	Trade, KNN ($k = 7$)
Urban Pop.	0.272**	0.363***
	(0.111)	(0.111)
Left Seats in Gov.	0.010	0.008
	(0.007)	(0.007)
Election Year	0.112	0.155
	(0.509)	(0.513)
GDP per capita	−0.092	−0.086
	(0.074)	(0.074)
GDP Growth	−0.246**	−0.224*
	(0.105)	(0.106)
Unemployment	0.306**	0.350***
	(0.103)	(0.103)
Inflation	−0.487***	−0.459***
	(0.032)	(0.032)
Petro Rents	0.716	0.793
	(0.523)	(0.527)
Gov. Debt	0.010	−0.004
	(0.016)	(0.016)
Spatial Lag	0.313***	0.300***
	(0.061)	(0.090)
Log likelihood	−2831.312	−2838.117
BIC	5737.078	5750.688
N	870	870

Standard errors in parentheses; $^{*}p < 0.050$, $^{**}p < 0.010$, $^{***}p < 0.001$ (one-sided).