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Documenting energy flows between states: The Global Energy Relations Dataset (GERD), 1978–2014

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ABSTRACT

Being the most globally traded commodity in terms of monetary value, energy remains one of the important shapers of interstate relations. States' quest to secure exports and imports of energy resources and the resultant efforts to govern energy flows have created numerous phenomena that have been of immediate interest to international relations (IR) scholars. However, few studies have so far aimed to systematically examine how energy relations shape global politics. One important reason for this paucity relates to the lack of a dataset with wide spatiotemporal coverage that allows for such systematic analysis. The Global Energy Relations Dataset (GERD), featured in this study, aims to facilitate systematic analyses of energy relations in IR. The dataset offers yearly energy flow data for all country-pairs around the globe between 1978 and 2014. The data are compiled from major international and national agencies that offer reliable data on energy trade. Standardized over megajoules, the data are offered in directed-dyadic (exporter-importer) and monadic (country-only) format. The data are further broken down by resource (i.e., coal, oil, gas, and electricity) whenever possible. Preliminary analyses indicate energy relations exhibit considerable variance among pairs of states and over time, and that trade in some energy resources may pacify relations more than others. Correlating this variance with canonical variables used in international relations points to promising areas of research.

Al ser el producto más comercializado en todo el mundo en términos de valor monetario, la energía sigue siendo uno de los principales factores que determinan las relaciones entre los estados. El afán de los estados por garantizar las exportaciones e importaciones de los recursos energéticos y las acciones resultantes para controlar los flujos de energía crearon numerosos fenómenos que generaron un interés inmediato en los especialistas en relaciones internacionales (RR. II.). Sin embargo, son pocos los estudios que, hasta ahora, analizaron de manera sistemática cómo las relaciones en materia de energía configuran la política mundial. Un motivo importante de esta escasez de estudios es la falta de un conjunto de datos con una amplia cobertura espacio-temporal

KEYWORDS
Data; dependence; energy; IPE; trade

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Supplemental data for this article can be accessed here.

que permita dicho análisis sistemático. El Conjunto de datos de las relaciones energéticas mundiales (Global Energy Relations Dataset, GERD), presentado en este estudio, tiene como objetivo facilitar el análisis sistemático de las relaciones en materia de energía en las RR. II. El conjunto de datos ofrece todos los años información sobre el flujo de energía para todos los pares de países del mundo entre 1978 y 2014. Los datos proceden de los principales organismos internacionales y nacionales que ponen a disposición información confiable sobre la comercialización de la energía. Estandarizados en megajulios (MJ), los datos se ofrecen en formato diádico (exportador-importador) y en formato monádico (país solo). Los datos se desglosan, además, por recursos (es decir, carbón, petróleo, gas y electricidad), siempre que sea posible. Los análisis preliminares indican que las relaciones energéticas presentan una considerable variación entre los estados pares y con el paso del tiempo, y que la comercialización de algunos recursos energéticos puede pacificar las relaciones más que otros. La correlación de esta variación con las variables canónicas utilizadas en las relaciones comerciales es un indicador de campos de investigación prometedores.

En tant que produit de base occupant la plus grande place dans le commerce international en termes de valeur monétaire, l'énergie reste l'un des facteurs importants qui façonnent les relations interétatiques. La quête de sécurisation des exportations et des importations de ressources énergétiques des États et les efforts qui en résultent pour régir les flux énergétiques ont donné lieu à de nombreux phénomènes qui ont suscité un intérêt immédiat des chercheurs en relations internationales (RI). Cependant, seules quelques études ont jusqu'ici eu pour objectif d'examiner systématiquement la manière dont les relations énergétiques façonnaient la politique mondiale. L'une des principales raisons de cette insuffisance est l'absence d'un jeu de données à large couverture spatio-temporelle qui permettrait une telle analyse systématique. Le Jeu de données sur les relations énergétiques mondiales (GERD, Global Energy Relations Dataset) présenté dans cette étude a pour objectif de faciliter les analyses systématiques des relations énergétiques en RI. Ce jeu de données fournit des données annuelles sur les flux énergétiques de 1978 à 2014 pour toutes les paires de pays du monde entier. Les données ont été compilées après avoir été recueillies auprès des principales agences nationales et internationales consacrées à l'énergie qui offrent des données fiables sur le commerce d'énergie. Les données sont normalisées en mégajoules (MJ) et fournies au format dyadique avec direction (exportateur/importateur) et au format monadique (pays seulement). Elles sont par ailleurs réparties par ressource (c-à-d, charbon, pétrole, gaz et électricité) dès que possible. Les analyses préliminaires indiquent que les relations énergétiques présentent une variance considérable entre les paires d'États et au fil du temps et que le commerce de certaines ressources énergétiques plus que d'autres peut pacifier des relations. La corrélation de cette variance avec des variables canoniques utilisées en relations internationales met en évidence des domaines de recherche prometteurs.

Introduction

Energy is arguably the most valuable traded commodity in the world. Energy resources are integral parts of numerous production chains, and hence key to a nation's economic prosperity. Moreover, energy resources are of paramount importance for military activity, and thus, for national security. Given their strategic importance and inherent characteristic of being geographically endowed, securing reliable and affordable access to energy resources may significantly impact the destiny of a nation.

Given states' intense competition over energy resources, understanding when and how energy relations affect international politics continues to remain relevant. Energy trade and governance may have notable impacts on the international political economy, the formation and activity of various international organizations, how states conduct foreign policy, and the incidence and severity of the international conflict. While scholars and policymakers have extensively debated the link between international politics and international energy trade in the framework of energy security, systematic quantitative analyses examining how energy relations shape interstate relations remain few. The lack of a systematic dataset with a global and wide temporal coverage has so far confined studies using dyadic variables of energy relations mostly to case studies (Allison, Light, and White 2006; Aalto 2008; Harsem and Harald Claes 2013).[1]

The Global Energy Relations Dataset (GERD) features annual data on how states relate to each other in terms of energy.[2] The dataset covers the globe for the years between 1978 and 2014. The dataset reports both monadic (country-level) energy data and directed dyadic energy resource flow. The monadic version reports the yearly total primary energy supply of countries (TPES), used to gauge their consumption levels, as well as the production, export and import figures for four main sources, namely coal, oil, gas, and renewable energy including nuclear.[3] Dyadic energy trade flows correspond to annual gross energy imports of a country from a given partner, as well as a breakdown of these imports by four primary energy resources, namely coal, oil, natural gas, and electricity.[4]

GERD is based on high-quality data from various international and national agencies, such as the International Energy Agency, United Nations, Energy Information Agency, CEDIGAZ, and the World Bank.

[1]Two recent important exceptions are Lee and Mitchell (2019), and Gökçe, Hatipoglu, and Soytas (2021).

[2]The dataset (in .dta format) can be accessed at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/TTOXMB or at https://apps.kapsarc.org/kgerd.

[3]International Energy Agency defines TPES as "the overall energy supply available for use in a country." TPES is calculated as national production + imports − exports of energy + stock changes.

[4]Flows of oil are reported based on whether oil is traded as crude or by-product. Likewise, natural gas flows are reported based on whether they are transited via pipelines or in liquified form.

None of these institutions, however, offer exhaustive coverage of countries (both in monadic and dyadic forms) for the last five decades on all four primary energy resource types. Combining these datasets to extend coverage, aggregating various subgroups of energy sources into one of the four main categories and standardizing data collected in various units over megajoules constitute the main contributions of GERD.

Preliminary analyses of GERD reveal interesting findings. Energy relations of various dyads seem to follow different trajectories over time. While a specific exporter's share in an importer's overall energy consumption may soar over time for some dyads, this figure remains relatively stationary or follows a cyclical nature for some others. An importer's relative reliance on different suppliers for specific resources may also change over time. In addition, some of these changes also seem to follow (and possibly respond to) certain global political events and economic shocks. These initial findings further motivate our endeavor to enable scholars to use, as well as develop, novel measures of energy relations in analyses of interstate behavior.

This paper proceeds in five sections. The next section presents a brief survey of how the empirical literature on energy and interstate relations motivates the need for GERD. The third section summarizes the process of data compilation and highlights some of the major challenges and decision points encountered during this process. Preliminary analyses of the data and a discussion on how the dataset can be utilized in different ways are presented in the fourth section. The last section concludes by summarizing the paper and pointing to potential challenges as the global energy landscape evolves into the future.

Energy and Empirical International Relations: An Emerging Field

In a world where energy relations between states remain in constant flux, scholars and policymakers need a better understanding of how energy relations shape interstate relations. Interestingly, the scholarly interest on how energy *systematically* affects interstate relations has been recent (see Colgan 2010, 2011; Ross and Voeten 2016). Initial studies have focused on specific cases to parse out causal mechanisms between energy security and the foreign policies of states (Kalicki and Goldwyn 2005; Daojiong 2006; Krickovic 2015). While these cases are of great importance to policymakers, generalizing the findings inevitably runs into validity issues (King, Keohane and Verba 1994).

The first wave of systematic analyses tried to associate attributes of a single state to its behavior in the international system (Colgan 2010; Ross and Voeten 2016). Such monadic approaches, in line with McDonald (2007), demonstrated that higher levels of *rentier* income increase states' discretion in their foreign policy endeavors. Specifically, budgetary discretion that natural resources, in general, and hydrocarbons, in particular, provide allows the pursuit of aggressive foreign policy against other states. Relying on a similar logic, another strand focused on systemic variables such as the level and volatility of global oil prices, and their effect on state behavior (Hendrix 2017).

While considerably improving our scholarly understanding of how energy shapes the international arena, these initial waves of analyses mostly use monadic data, and thus, ignore the possible impact of other parties' positions in determining a state's behavior. Much of academic and policy debates, however, are concerned with how energy connects one specific country or region to another. Using dyadic variables, therefore, opens a whole new dimension for the analysis of the role energy plays in interstate relations. Variables such as what percent of its annual TPES a country imports from another, how much of a state's oil consumption is provided by a specific oil exporter, or what portion of coal exports of an exporter go to a specific importing country in a given year may enable analysts to run cross-sectional and/or time-series tests of how energy markets relate to various economic and political phenomena. Such dyadic approaches have constituted the empirical gold standard in answering interesting research questions in IR, such as whether increased bilateral trade ties reduce the incidence of conflict between two states (Oneal and Russett 1997), economic sanctions against allied states are likely to be more successful (Drezner 1999), and sitting on the UN Security Council increases the level of participation in IMF programs for a non-permanent member (Dreher, Sturm, and Vreeland 2009), among others.

Recent studies have laid the considerable groundwork for systematic analysis of energy flows and interstate relations by offering new measurements, such as states' net oil positions (Colgan 2021) or their dependence on natural resources in producing electricity (Lee 2018). While such measures allow robust quantitative inquiry into the relationship between interstate energy flows and interaction, they either tend to allow only for monadic analyses (e.g., Colgan 2021), rely on the quite limited spatiotemporal domain (e.g., Lee 2018), and/or focus on certain types of energy sources (e.g., San-Akca, Sever, and Yilmaz 2020). Our dataset contributes to these efforts by offering both monadic and dyadic data on flows that cover a wide spatiotemporal domain. In addition to our variables derived from aggregate energy flows between two countries, we also develop separate measures each of which is based on one of the four main modes of "energy carriers," namely coal, oil, natural gas, and electricity.

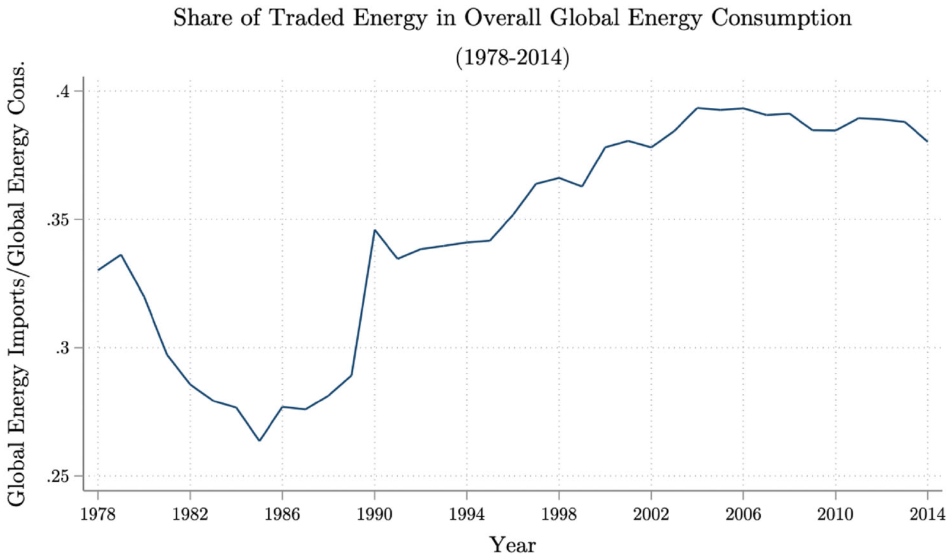

Figure 1. Share of traded energy in overall global consumption (based on gross calorific values) (Source: IEA).

Various theoretical, empirical, and policy-relevant reasons underpin our decision to base our dataset on these four types of interstate energy flows. Coal, oil, gas, and electricity flows account for almost all the energy trade between countries.[5] The inclusion of coal and electricity also renders historical continuity to our dataset. Coal was the main energy resource until the early 20th century in the world, after which oil overtook and became the world's primary source of energy supply. Currently, the world derives about 33% of its energy from oil, 27% from coal with gas closely following at 24% (IEA 2020). Renewables, including hydro and nuclear, provide a robust 16%. Figure 1 shows that in 2014, 76% of all energy consumed in the world crossed international borders at one point. While the economic recession in the early 1980s pulled this figure down to 55%, increasing levels of globalization minimized the effect of future economic downturns on international energy trade. Figure 2 affirms that oil remains the most traded energy resource (in terms of gross calorific values). Still, natural gas and coal have been consistently taking a larger share of the global energy trade. The economic successes of developing nations (especially China and India) during the early 2010 economic boom catapulted coal over natural

[5]Hydrogen, nuclear fuels, and rare earth minerals key to the generation of renewable energy are also important energy commodities that are traded internationally, but not included our dataset. Hydrogen's share in global energy flows is minute and has picked up only very recently. The amount of electricity "foreign-sourced" nuclear fuels produce is minimal, and the number of clients seeking such imports is quite limited. Rare earth minerals relate to capacity building and operation of renewable power plants and are not carriers of energy themselves. Nonetheless, as technology in energy production and transmission evolves, future studies should account for novel forms of interstate energy flows.

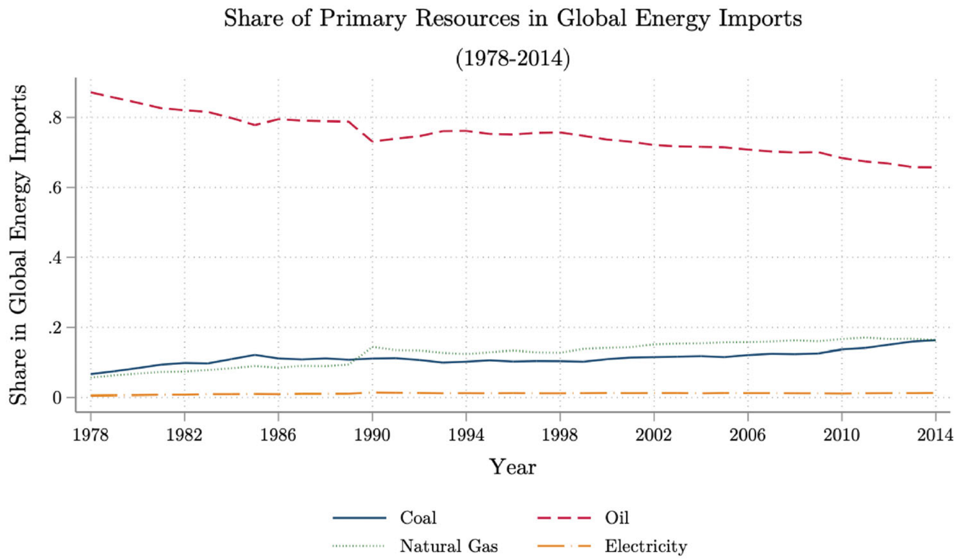

Figure 2. Share of primary resources in global energy imports (based on gross calorific values) (Source: IEA).

gas as these countries resorted to cheaper and more available solutions to satisfy their fast-increasing energy needs.

While accounting for about 2% of global trade in energy in pecuniary terms, cross-border trade in electricity has exceeded $30 billion dollars worldwide both in 2014 and 2019, the end year of our dataset, and the last years for which data are available, respectively (World Bank 2020). These traded "electrons" are mostly generated from renewable resources.[6] For example, Paraguay's annual income from its hydroelectricity exports has hovered around 2 billion USD over the last decade (World Bank 2020). Bhutan derives about one-fifth of its GDP from hydroelectric exports to neighboring countries (IRENA 2019, xi, 5). Britain and France have been wheeling electricity to each other for decades, where Britain's imports from France, mostly provided by nuclear power, have often exceeded 5% (Hatipoglu, Muhanna, and Efird 2020). Such trade in electricity may create and respond to political tensions. The recent renegotiation between Paraguay and Brazil over the pricing of electricity led to political tension within and between the trading partners (The Economist 2019). In 2017,

[6]To be precise, electrons need not necessarily travel from one point to another for electricity to transmit. Trade of electricity can also be perceived a service. Akin to insurance services (Fuentes, Blazques, and Adjali 2019), should the need occur, some contracts oblige the provider to meet the extra amount of electricity peak demand requires. Alternatively, an electricity exporter can specifically provide the service of grid balancing. Such exchanges need not necessarily be priced on the number of electrons transferred. Rather, some of these services may charge a flat fee. An importer's dependence on such services at critical moments may not be necessarily reflected in our dataset. As the energy transition progresses in the world, similar data collection endeavors should take such theoretical priors into account. The authors would like to thank one of the anonymous reviewers for raising this point.

Ireland and France initiated the Celtic Interconnector project, which aimed to connect the two countries with direct electricity transmission cables, as Brexit "threaten[ed] to isolate Ireland physically from the rest of the European energy market because all its imports of gas and electricity flow via the UK" (Ward 2017).

The level of fungibility of these four resources in global markets also varies among each other and over time. This variance is valuable for analysis, especially for questions relating to energy dependence. Coal has been readily available in global markets for well over a hundred years. While early debates on energy security focused on availability, accessibility, and affordability of oil (e.g., Yergin 2011), unconventional production methods (e.g., fracking) "faded" the interest in the peak oil supply debate (Bardi 2019, 257). Despite recent investments in LNG terminals, natural gas flows are highly specific between the two trading countries, for which a global price does not exist, hence do not exhibit a truly global market (Tsafos 2018). The structure of the international electricity flows is quite different than that of hydrocarbons. Inventories are virtually non-existent,[7] consumption and often the trading of electricity occur instantaneously. Substitution patterns for imported electricity differ from that of hydrocarbons. Transit countries, if any, also hold considerable leverage over the trade between a trading dyad.[8]

Finally, exogenous events may also lead to substitution between these four resources. Following the 5 G ban against Huawei in 2020, for instance, China halted coal imports from Australia, its second-biggest coal supplier. Instead, China had to increase inland coal production and imports from other suppliers. The uncharacteristically cold weather in both Asia and Europe during the winter of 2020–2021 increased the demand for LNG and electricity, leading to spikes in spot prices for both. Production outages in LNG supplier countries, delaying shipments, and lack of resilience in renewables during cold/cloudy/low-wind spells also prompted energy importers to increase their demand for (and production of) oil, coal, and nuclear energy. GERD allows us to assess such substitution patterns among energy resources that may emerge due to political events such as militarized disputes, sanctions, or alliance formations.

Compiling Data: Resources and Procedures

The Global Energy Relations Dataset is comprised of two cross-sectional time-series datasets. The dyadic version focuses on energy resource flows

[7]Large-scale battery and other forms of storage, such as pumped hydro, are at their infancy. These technologies were virtually non-existent for the period our dataset covers.

[8]Transit countries for gas, and, to a lesser extent, oil may also hold such leverage.

from one county to another. Often, these flow variables are of interest to researchers as a ratio to overall national levels, such as the share of Chinese natural gas consumption supplied by Qatar in a given year. Therefore, GERD also includes monadic data standardized over gross calorific units for consumption, production, and import/export figures at the national level.[9]

Dyadic Data

The energy relations dataset draws data from a multitude of resources. The International Energy Agency (IEA) database and its annual reports constitute our primary source for monadic- (i.e., national), and dyadic-level energy statistics. At the dyadic level, the IEA provides energy trade (i.e., imports and exports) data of thirty-four OECD-member countries—it reports energy flows only if at least one side is an OECD-member country. In other words, the IEA does not provide figures on energy trade between two non-OECD countries.[10] These data are also broken down into four primary resource types (coal, oil, natural gas, and electricity). The IEA continues to collect such high-quality data and reports them each year, hence easing future efforts to extend our dataset.[11]

For coal, the IEA provides yearly export data from thirty-four OECD-member countries to ninety-six destination countries and imports to OECD members from seventy-six origin countries. Coal trade data are reported in kilotons of eleven different sub-types (e.g., lignite, coke, etc.) or by-products starting from 1978. Similarly, starting from 1971, oil trade data are regularly provided as export figures from thirty-four OECD-member countries to ninety-five destination countries, and import figures to OECD members from 104 origin countries. The IEA reports oil trade data in kilotons for crude oil, and for twenty-one different sub-types or by-products of oil. For natural gas trade, both in gaseous and liquified forms, the IEA provides yearly export data in volumes from thirty-four OECD members to sixty-six destination countries in a regular manner starting from 1970. Unlike the way that it reports import figures for coal and oil, the IEA provides natural gas import figures between 135 countries, if any, without requiring one of the sides to be an OECD member. These gas figures from the IEA are, however, available for a temporally limited period from 1993 onwards. Electricity trade flows, which are reported in megawatt-hours, are based on data reported by OECD countries—imports from and exports to fifty origin/destination countries of OECD members.

[9]In our online codebook, readers can find a detailed description of the data compilation procedures and coding in the GERD: (https://www.dropbox.com/s/8t2jt3ui07aw1pp/GERDCodebook.docx?dl=0).

[10]The exception is for natural gas import figures as discussed below.

[11]We used the 2016 edition of IEA data while compiling GERD.

To extend the spatiotemporal coverage in dyad–years, especially for non-OECD pairs, we used the CEDIGAZ and UN Comtrade databases as supplemental data sources. CEDIGAZ provides dyadic trade statistics of gaseous and liquified natural gas, as well as national consumption and reserve levels, for more than 120 countries starting from 1950. CEDIGAZ reports dyadic figures for natural gas trade if such a trading relationship exists within a dyad in a given year. Although its reporting dates back to 1950, regular yearly reporting starts from 1975. UN Comtrade database constitutes our last resort for remaining observations or missing entries for all primary resource types.

The interstate imports and exports statistics of UN Comtrade are based on reports of national statistical authorities of the member states.[12] It also reports monadic trade figures, i.e., total exports/imports of a country on a yearly basis. Trade figures are reported in current United States (US) dollars and are mostly supplemented with relevant amounts in weights and volumes (or in KWh for electricity). A typical observation in the UN Comtrade dataset, for instance, would report exports of oil from Iraq to Turkey in 2011 in terms of value (U.S. dollars), volume (in liters), and net weights (in kilograms). However, irregularities often exist in reporting. Using inconsistent units across dyads is one such irregularity. For instance, natural gas figures can be reported only in liters for one pair, and only in kilograms for another. Such irregularities are standardized using conventional conversion tables published by the IEA. Occasionally, trade figures are reported in incompatible units. For instance, electricity trade figures might be reported in kilograms. These cases are treated as missing.

Despite being spatiotemporally comprehensive, UN Comtrade dyadic trade data have some issues worth noting. First, intermittent reporting of trade figures leads to missing data points. Unlike the IEA, the UN Comtrade does not provide estimates for missing entries. Even if trade figures are reported regularly, discrepancies might exist in commodity classifications. Moreover, total amounts or values of commodities traded for a given reporter country may not tally with its total trade figures due to confidentiality concerns over the trade of certain commodities. Likewise, figures reported by one partner of a trading dyad may not match with those reported by the other partner due to incompatible calendar years, varying valuations, or inconsistent commodity classifications. UN Comtrade,

[12] In the UN Comtrade database, export and import figures include amounts and values of re-exports and re-imports. Re-exports are goods that are initially imported from Country A by Country B, then re-sold to Country A. Re-imports are goods that are initially exported by Country A to Country B, then repurchased by Country A. Re-exports and re-imports occur frequently in energy trade; a re-exporter country often processes certain goods (e.g., oil) and sells the refined product back to the re-imported country. For instance, Turkey buys crude oil from Iraq, processes this oil in its refineries, and sells certain oil products back to Iraq. In this example, refined oil products are classified under re-exports for Turkey, and re-imports for Iraq.

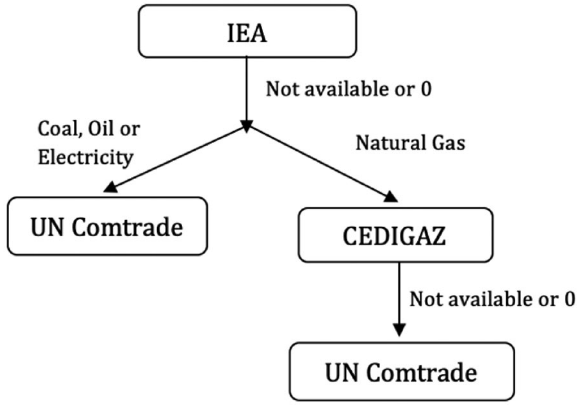

Figure 3. The order of preference in compiling dyadic energy flows.

unfortunately, does not correct these discrepancies. For our dataset, we selected the highest reported figure between the two directions of the recorded trade flow.[13] Lastly, a reported trade may not necessarily indicate the final destination for the goods in question.

Considering data availability for all types of energy resources (i.e., coal, oil, gas, and electricity) with the greatest spatial extent possible, we started the coverage for dyadic energy trade from 1978. Figure 3 shows the order of preferences while compiling a dyadic energy trade dataset. The level of reliability of reported figures determined the ordering in Figure 3. The IEA and CEDIGAZ databases report data after energy experts verify the authenticity and reliability of data. UN Comtrade, on the other hand, mostly relies on countries' self-reports.

Monadic Data

Figure 4 shows the order that we follow while compiling resource-based monadic figures. The IEA database is, again, our primary source while compiling resource-based monadic-level data on consumption, production, total exports, and imports figures. To extend the spatial coverage of the data beyond 150 states offered by the IEA for the period 1978–2014, we followed a similar order as we did in compiling dyadic data. For consumption, production, and trade figures of natural gas, we used the CEDIGAZ dataset, which added 407 country-year observations to our IEA-based seed data.

The United States Energy Information Administration (EIA) was the next source we turned to for further monadic data for coal, oil, natural gas,

[13]Getting averages of two different reported figures is an alternative approach here. However, we prefer not to lose any available information reported in the data.

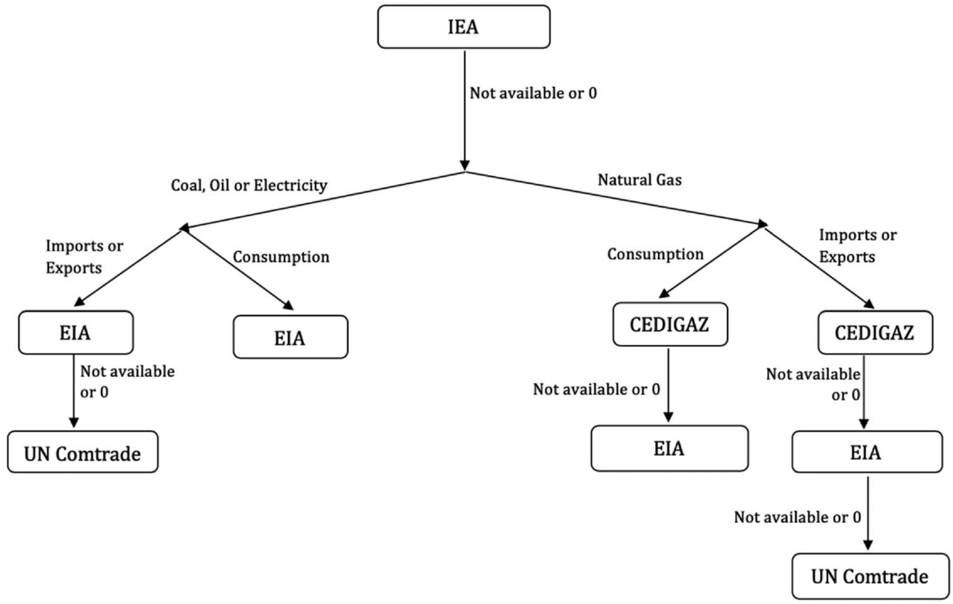

Figure 4. The order of preference in compiling monadic energy trade and consumption figures by resource types.

and electricity. The EIA database reports monadic energy consumption, production, total exports, and imports figures of 218 countries with respect to four primary energy resources from 1980 onwards.[14] Using the EIA database, we added 1394 country-year observations to our existing data. Our last resort for monadic trade data (i.e., total exports and imports) is again the UN Comtrade.[15] Inconsistencies similar to those discussed for dyadic figures also exist in monadic energy data of UN Comtrade.

The energy trade (import and export) figures often make sense in relation to that country's overall energy consumption. Energy security, for instance, is often proxied by a variant of the ratio of imports to a country's overall annual TPES (see Kruyt et al. 2009, for an extensive review on how energy security is operationalized). Exports as a percent of overall consumption have also become an increasingly salient topic; recent studies show that increasing levels of domestic energy consumption in energy-exporting countries have been eating away potential export revenues, often posing a risk to public finances of these countries (Krane 2019).

In addition to resource-based consumption, production, and trade data, we compiled national gross energy consumption figures for our period of interest. The IEA database is our primary source in this endeavor. To

[14]The EIA offers dyadic data for only between the United States and its trading partners. These data were already curated from the IEA database.

[15]As expected, UN Comtrade does not report monadic consumption and production figures.

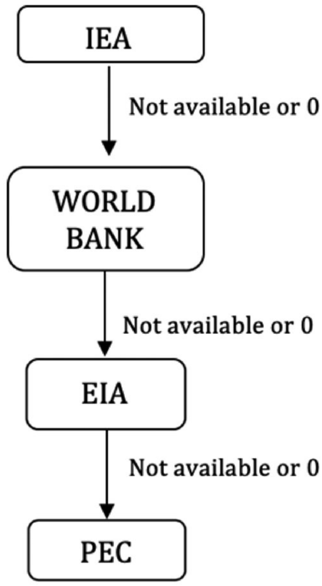

Figure 5. The order of preference in compiling national gross energy consumption figures.

increase our coverage, we also used the World Bank database. The World Bank database reports yearly national gross energy consumption figures in million tons of oil equivalent (mtoe) using the IEA's sources, while including additional countries such as Djibouti or the Marshall Islands from 2007 to 2011. Despite these inclusions, overall temporal coverage of the World Bank data remains limited, particularly for sub-Saharan and small countries. To increase this coverage, we utilized another dataset, namely the National Material Capabilities dataset. This dataset reports the Composite Index of National Capacity (CINC) scores which quantify national material capabilities on a yearly basis (Singer 1988). One of the components of the CINC scores is the Primary Energy Consumption (PEC) measure featured in metric ton coal equivalent (tce) covering the period of 1816–2012. While reporting national gross energy consumption statistics, PEC data rely on aggregate consumption figures based on the four primary energy sources (i.e., coal, oil, gas, and electricity). These data were used to fill in missing entries for the national gross energy consumption variable. Figure 5 summarizes the ordering we used to compile our national gross energy consumption variable.

Standardization across Data Sources

The databases discussed above use different commodity-naming and country-coding schemes and/or inconsistent measurement units. Matching country-year identifications was another common problem as differences existed regarding the years of foundation or dissolution of various states.

Table 1. Availability of information and reporting units in databases based on resource types and levels of analysis.

	IEA		UN Comtrade		CEDIGAZ		EIA		World bank		PEC (CINC)	
	Available	Unit	Available	Unit	Available	Unit	Available	Unit	Available	Unit	Available	Unit
Dyadic trade												
Coal	Yes	kt	Yes	kg								
Oil	Yes	kt	Yes	kg; lt								
Nat gas	Yes	Mcm; Tj	Yes	kg; lt	Yes	Bcm						
Electricity	Yes	MWh	Yes	kWh								
Monadic total imports/exports												
Coal	Yes	Tj	Yes	kg			Yes	Tj				
Oil	Yes	ktoe	Yes	kg; t			Yes	Mb/d				
Nat gas	Yes	Tj	Yes	kg; lt	Yes	Bcm	Yes	Tj				
Electricity	Yes	Tj	Yes	kWh			Yes	BkWh				
Monadic total consumption												
Total	Yes	Ktoe					Yes	Qbtu	Yes	toe	Yes	ktce
Coal	Yes	Tj					Yes	Tj				
Oil	Yes	Ktoe					Yes	Mb/d				
Nat gas	Yes	Tj			Yes	bcm	Yes	Tj				
Electricity	Yes	Tj					Yes	BkWh				

Synchronization and standardization of variables across these data sources constituted our next step so that we could merge, append, and sum variables to derive consistent series for energy figures.[16] Table 1 tabulates the utilized sources with respect to data availability and the units used the data were originally reported in.

One of the novel aspects of our dataset is the reporting of energy relations between countries in standardized gross calorific value, not monetary value, across different commodity types. In most policy debates, energy dependence on a supplier is often discussed in terms of the level of energy that needs to be satisfied, with the resulting trade imbalance voiced as a secondary concern (Narula and Reddy 2015; Nance and Boettcher 2017). In addition, energy demand appears to be inelastic to price in the short term (see, inter alia, Kim, Kim, and Radoias 2017; Lijesen 2007; Galindo 2005). At a time of crisis, then, the policymakers in an importing country would be more concerned with satisfying the country's immediate needs. As such, policymakers would be more concerned with satisfying energy needs regardless of the price in the short term. The amount of energy in terms of calorific values, therefore, would be of immediate concern to policymakers, and would better reflect the leverage the exporters might have on a specific importer. Furthermore, energy prices are not transparent in many cases (Stulberg 2012), side payments are not reflected and may often be subject to non-currency barters (Friman 1993; Krasnov and Brada 1997).

We developed a detailed and robust conversion procedure for each commodity to be converted to calorific values (megajoules). Reconciling

[16]Please refer to the online codebook for further details.

Table 2. Conversion table used to synchronize dyadic trade figures by product types and units.

GERD product groups	IEA	UN Comtrade SITC Rev. 2	UN Comtrade SITC Rev. 3	MJ/kg		
Anthracite	Anthracite	Anthracite	Anthracite	30		
Other coal	Bituminous coal Coking coal Sub-bituminous coal	Other coal	Other Coal	25.1		
Lignite	Lignite	Lignite	Lignite	14		
Peat	Peat	Peat	Peat	10		
High coal products	Oven coke Patent fuel Coal tar	Coke and semi-coke	Coke and semi-coke	29		
Low coal products	Briquettes of brown coal Peat products	Briquettes of coal/lignite/peat	Briquettes of coal/ lignite/peat	12		
				MJ/kg	kg/lt	
Crude oil	Crude petroleum NGLs Refinery feedstocks Additives/oxygenates Other hydrocarbons	Crude oil, non-refined petroleum	Crude oil, non-refined petroleum Petroleum/ hydrocarbon gas	45.31	0.853	
High oil products	Aviation gasoline Motor gasoline Gasoline type jet fuel Kerosene type jet fuel Gas/diesel oil Fuel oil Other kerosene Refinery gas Naphtha	Refined petroleum products	Heavy petroleum products	47.3	0.811	
Low oil products	White Spirits & SBP Lubricants Bitumen Paraffin waxes Petroleum coke Other products	Residual petroleum products	Residual petroleum products	39.5	0.95	
LPG	LPG Ethane	Liquid propane & butane	Liquid propane & butane	50.8	0.53	
				MJ/kg	kg/lt	MJ/cm
Natural gas, pipe	Natural gas, gaseous	Petroleum gases and other gaseous hydrocarbons	Natural Gas (Gaseous)	Norway = 52.6 Netherlands = 45.2 Russia = 54.42 Others = 50.7	0.00077	Norway = 42.5 Netherlands = 35.4 Russia = 37.8 Algeria = 39.2 Others = 38.95
LNG	LNG	Liquefied gaseous hydrocarbons	Liquefied Natural Gas (LNG)	54.4	0.45	40
				MJ/MWh		
Electricity	Electricity	Electricity	Electricity	3600		

commodity types across various data sources and different time periods was a notable challenge. Table 2 tabulates the conversion factors we utilized for different types of energy sources. Whenever the sub-types of a source were known (e.g., lignite vs. coke or the Netherlands' gas via pipeline vs. Russian gas via pipeline), we used specific conversion rates for those sub-types. When only general source type was known (e.g., coal or oil), we used average figures.

Missing Data

Despite our meticulous efforts and methodological collection of data from various resources, non-trivial percentages of energy flow data between the two countries remained as missing. Multiple imputations are feasible for those who wish to do so. One can also replace certain missing variables with "theoretically driven" zeros. To illustrate, any oil flow from a land-locked country to another non-neighboring land-locked country may be assumed to be zero. Note that we cannot make a similar assumption for countries with ports, since oil-forwarding is a common phenomenon. Gas figures can follow a similar practice, as almost all gas flows from a supplier to a consumer that traverses a third country through a pipe is accounted for. For electricity, researchers may choose to impute 0 for states that are deemed as "technically irrelevant," such as between Bolivia and Nepal. Such a definition could relate to pairs of states that do not share a land border and are separated by the sea by more than 200 miles. It is important to realize that electricity can be transferred under the sea for smaller distances, as is the case between France and Great Britain. We choose not to present any of these ameliorations in this data feature as we believe empirical strategies against missing data should be led by the research question at hand (Table 3).

Exploring Trends in Energy Data: An Initial Skirmish

To show how various country-dyads can exhibit different trends with respect to their energy relations, we utilize the energy dependence index developed in Gōkçe, Hatipoglu, and Soytas (2021). This index calculates the share of energy imported from country X to country Y as a percentage of country Y's overall energy supply (TPES), calculated in megajoules (see Supplemental Appendix A for a more detailed discussion on the construction of this index). In doing so, the index aggregates coal, oil, gas, and electricity imports from a specific exporter to that importer country. Reimports are treated as separate transactions between the two countries. Similarly, forwarded freights are counted as separate transactions between an exporter

Table 3. Summary of missing observations and descriptives* by variables in the GERD.

Variable name	Missing	Non-missing	Percentage	Mean	Std. Dev.	Min	Max
Dyadic variables							
Dyadic coal import	502,654	1,234,927	28.9	478.20	17362.61	0	3401981
Dyadic oil import	839,331	898,250	48.3	4753.60	73827.70	0	2.84e + 07
Crude oil				3699.55	68142.75	0	2.84e + 07
By-products				1505.19	24134.73	0	9615770
Dyadic natural gas import	271,646	1,465,935	15.6	585.55	22515	0	4239474
Pipeline				443.36	20944.05	0	4239474
LNG				153.25	8600.68	0	2993390
Dyadic electricity import	371,632	1,365,949	21.4	90.45	17045.34	0	1.06e + 07
Monadic variables							
Total coal imports	169,017	1,568,564	9.7	83063.63	385616.3	0	7624091
Total coal exports	190,925	1,546,656	11.0	90337.67	538177.7	0	1.02e + 07
Total coal consumption	191,547	1,546,034	11.0	544609.70	3548036	0	8.51e + 07
Total coal production	191,547	1,546,034	11.0	550292.1	3571202	0	7.91e + 07
Total oil imports	168,808	1,568,773	9.7	536010.3	1983329	0	3.00e + 07
Total oil exports	178,598	1,558,983	10.3	547489	1687360	0	2.10e + 07
Total oil consumption	196,704	1,540,877	11.3	708364.3	2871783	0	3.89e + 07
Total oil production	196,704	1,540,877	11.3	770930.3	2668864	0	2.63e + 07
Total natural gas imports	183,914	1,553,667	10.6	103158.2	414152	0	7902118
Total natural gas exports	194,679	1,542,902	11.2	105105.6	544928.3	0	1.13e + 07
Total natural gas consumption	194,304	1,543,277	11.2	424718.7	1964803	0	2.63e + 07
Total natural gas production	194,304	1,543,277	11.2	430246.1	2117929	0	2.74e + 07
Total electricity imports	194,667	1,542,914	11.2	8185.52	25048.65	0	530026.2
Total electricity exports	196,304	1,541,277	11.3	8151.1	28981.72	0	660571.3
Total electricity consumption	196,704	1,540,877	11.3	250147.7	1144251	0	1.94e + 07
Total electricity output	196,704	1,540,877	11.3	270535.8	1216640	0	2.05e + 07
Nuclear	706,425	1,031,156	40.7	176710	794552.3	0	9153622
Fossil fuels	196,704	1,540,877	11.3	178436.5	883166.5	0	1.54e + 07
Renewables	196,704	1,540,877	11.3	263190	928051.1	0	1.00e + 07
Total inland energy consumption	150,690	1,586,891	8.7	2006975	8423832	0	1.24e + 08

*Descriptives are reported in terajoules (TJ).

and a forwarder, and a forwarder and the importer. Finally, the data on the importer's annual TPES and individual energy consumption figures by source are obtained from the monadic version of GERD.[17]

Figure 6 presents trends for selected importer-exporter dyads and graphs to what extent each importer is dependent on the exporter's energy sources for its yearly TPES. The graph shows that energy relations between various dyads can follow different trajectories. The United States' dependence on Canadian energy sources, for instance, has shown a small but steady increase between 1978 and 2010, eventually reaching slightly above 10%. This increase has been more marked for Mexico's dependence on the United States, a major portion of which has been due to Mexico's reimport of processed fuel from United States refineries.

Germany and Turkey's energy relations with Russia, their main energy exporter, paint somewhat dissimilar pictures. Since its unification, Germany has significantly relied on Russian energy sources, predominantly gas. With the new millennium, this dependence has plateaued around 25%. The increase in Turkey's reliance on Russian energy exports, in particular gas, has been more pronounced. The installment of gas infrastructure in

[17]To calculate the energy dependence for the analyses presented below, we replaced all missing variables for energy flows with 0.

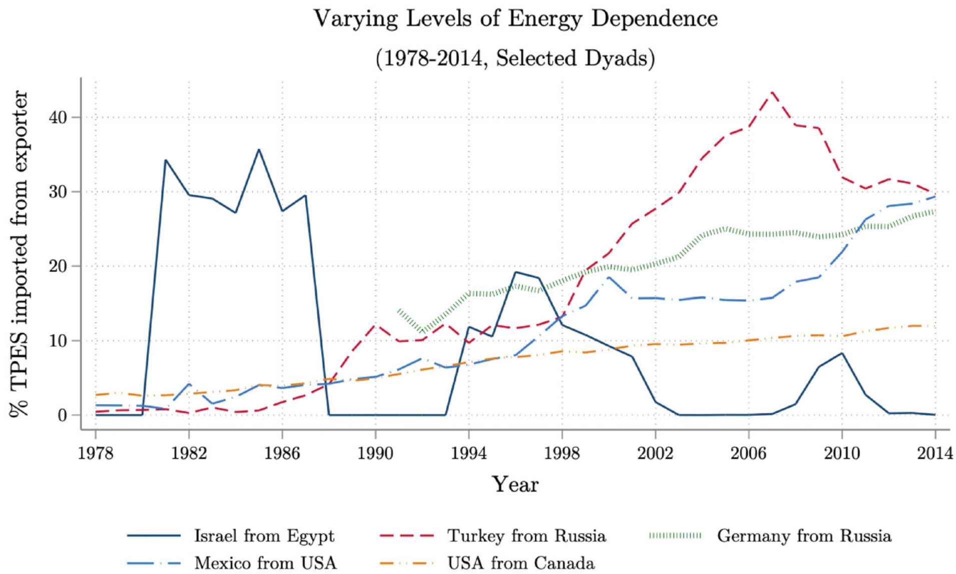

Figure 6. Varying levels of energy dependence across selected dyads (Source: GERD).

Turkish metropolitan cities and the installment of gas-fired plants during the 1990s catapulted gas as the main sources of Turkey's TPES. Turkey's sustained economic growth during the early part of the 2000s further bolstered Turkey's demand as Turkey's gas demand grew by a compounded rate of 5% for a decade (Rzayeva 2018). Due to existing and new infrastructure, Russia was poised to meet this increased demand from Turkey. The resulting dependence of Turkey on Russian energy peaked at around 43% in 2007 and settled around 30% since then.[18] The "pulsating" rhythm of Israel's energy dependence on Egypt constitutes another interesting story. These pulses roughly coincide with periods of rapprochement between the two countries. The events following 2012 make this dyadic relation even more interesting. The discovery of Israeli gas in the Eastern Mediterranean, coupled with political developments in Egypt, established Israel as a potential energy supplier of Egypt. In 2019, Reuters reported that Dolphinus Holdings of Egypt was planning to buy $15–$20 billion worth of gas from Israel's Tamar and Leviathan fields (Scheer 2019).

GERD also allows researchers to break down energy relations between two states by type and compare an importer's relations with various exporters at the same time. To illustrate this possibility, Figure 7 juxtaposes two figures. Figure 7a (left) illustrates how Japan's energy dependence on Saudi Arabia, Iran, and Russia has evolved over time. Figure 7b (right), on the other hand, compares the relative salience of these three suppliers of Japan

[18]A recent study by Gökçe (2019) finds that increasing levels of dependence on Russian gas are more likely to pull importer countries out of United States' orbit in the UN General Assembly votes.

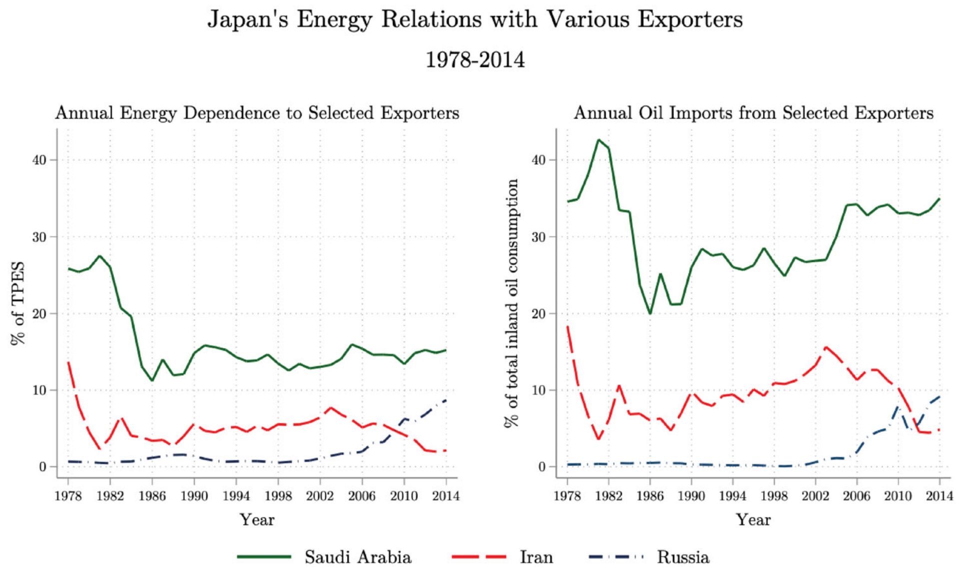

Figure 7. Japan and selected energy exporters (Figures standardized over MJs) (Source: GERD).

only with respect to oil. Both figures show that Saudi Arabia and Japan have been enjoying a special relationship in energy trade, although Japan's dependence on Saudi energy exports has decreased over time. In the early 1980s, at its peak, Japan derived about one-quarter of its TPES from Saudi oil; this oil also constituted about 40% of Japan's oil imports. Japan's dependence on Saudi energy exports showed a marked decrease over the next decade, mainly due to an increase in Japan's domestic energy production and diversification of its oil suppliers.

The spike that led to the peak in imports from Saudi Arabia in early 1981 is coterminous with the significant drop in Iranian oil supplies to Japan, which immediately followed the 1979 revolution. A similar trend is seen in the mid-2000s; looming international sanctions on Iran seem to have caused a drop in Iranian and an increase in Saudi oil exports to Japan. Finally, Russia seems to be emerging as an increasingly important energy supplier to Japan, surpassing Iran's overall energy exports to Japan in 2010 and oil exports in 2012. This increasing salience of Russian oil may suggest that the two countries may have started overlooking their geopolitical differences, especially over the Sakhalin Islands, and that Japan may be aiming to develop stronger ties with Russia against an increasingly assertive China (Vivoda 2009, 4619).

Besides allowing trade flows to be scaled by gross national figures, the monadic dataset allows many other inroads for analysis. Figure 8 juxtaposes two such uses. In In Figure 8a (left), we see the evolution of the share of fossil fuels over time in three selected countries' TPES. The figure indicates countries may follow different trajectories. Despite having undergone

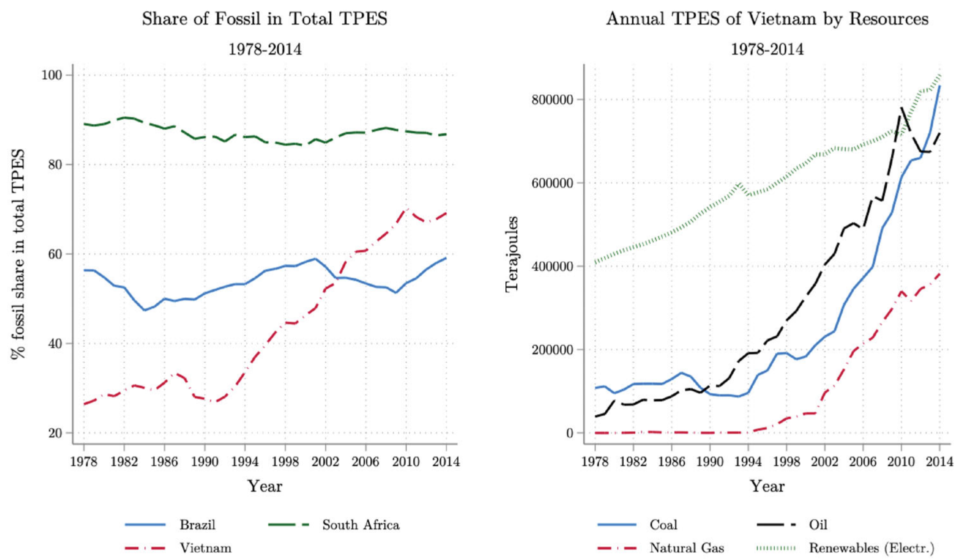

Figure 8. Illustrations for various uses of monadic data (Figures standardized over TJs) (Source: GERD).

fundamental changes in domestic politics and international orientation, South Africa is predominantly dependent on fossil fuels for its energy needs.[19] Investments in biofuels, hydro-projects, and, more recently, solar seem to have kept the share of fossil fuels in check for Brazil's TPES. While starting at a much lower level compared to the other two countries, the share of fossil fuels has shot up in Vietnam as it transitioned into a market economy and experienced subsequent economic growth. Figure 8b (right) further breaks down Vietnam's TPES trajectory by resource, namely coal, oil, gas, and renewables. As expected, renewable energy—hydroelectric in particular—has been playing an important role in meeting Vietnam's increasing demand for energy. Like many other developing countries that have successfully transitioned into market economies, Vietnam also has resorted to coal to fuel its development (Best 2017). While gas and oil play a limited role in Vietnam's TPES, the jump both resources exhibit with the start of the new millennium is noteworthy.

Preliminary Analysis of GERD: Overall Energy Dependence and the Likelihood of Militarized Interstate Dispute (MID) Initiation

In this section, we demonstrate how our dataset can be employed in a cross-national large-N setting to gauge the impact of energy dependence on

[19]Using matching estimators on GERD data, Hatipoglu and Soytas (2021) demonstrate that economic sanctions can lock the targeted state to carbon-intensive modes of electricity generation for decades by restricting their access to greener, but capital-intensive alternatives. The sanctions against the apartheid regime may, therefore, explain the "stickiness" of fossil fuels in South Africa's energy mix, despite the country being one of the most developed nations on the continent.

the likelihood of militarized dispute initiation. To that end, we use a dataset covering all possible dyadic interactions for each year from 1978 to 2012. Therefore, the unit of analysis is the directed-dyad–year. We are interested in the conditions influencing the decision of one state to initiate a militarized interstate dispute against another.[20] Information for dispute initiations comes from the MID 4.0 dataset (Palmer et al. 2015). The dependent variable is coded as 1 if the challenger initiates a MID against the target in a given year, and 0 otherwise.

The energy dependence index, our main independent variable, as defined in the previous subsection and is detailed in Supplemental Appendix A. We also run the same model with the three-year moving average (t, t-1, and t-2) of the same measure to account for possible lags with which markets may respond to disruptions in energy markets.

Our canonical control variables include contiguity (Stinnett et al. 2002), regime type (Jaggers and Gurr 1995), the relative power of a dispute initiator (Singer 1988), the major power status of the disputants (Small and Singer 1982), trade dependence of a dispute initiator to a target (Oneal and Russett 1997; Barbieri, Keshk, and Pollins 2009), level of economic development (Gleditsch 2002), foreign policy similarity (Voeten 2013), presence of an alliance (Gibler and Sarkees 2004), and cubic splines to control for temporal dependence (Beck, Katz, and Tucker 1998; Carter and Signorino 2010). We employ logistic regression with corrected standard errors based on clusters—the conventional estimation technique for models having a dichotomous dependent variable in a panel data set. To address potential endogeneity, we lagged our independent and control variables (Tables 4 and 5).

Models 1 and 2 indicate higher levels of energy dependence pacify a potential initiator against its exporter.[21] Our next set of empirical models asks whether this pacifying effect holds across different forms of energy flows. While the signs for the coefficients of all four resources appear negative, only those of natural gas attain conventional statistical significance. Both the coefficient and its standard error of electricity dependence turn out to be very high. These numbers suggest a trade-in electricity may indeed pacify an importer against its exporter, but the occurrence of such trade should become more common in the world for standard empirical models, like the one used above, to draw the healthy inference. The level of dependence on imports of oil and coal, for both of which a global market

[20]A MID is defined as an event “in which the threat, display, or use of military force […] by one member state is directed towards […] another state” (Jones et al., 1996, 168).

[21]Using a similar design and the GERD dataset, Gökçe et al. (2021) conduct a series of detailed statistical analyses to test whether and how increased levels of energy dependence pacify an importer. The authors contextualize their findings within a detailed discussion of the realist-liberal debate on economic interdependence and energy security.

Table 4. Energy dependence and militarized interstate dispute initiation.

	(Model 1)	(Model 2)
Independent variables$_{(t-1)}$	Dispute initiation$_{(t)}$	Dispute initiation$_{(t)}$
Energy Dep. of initiator	−1.237* (−1.77)	
Energy Dep. of Init. MA(3)		−1.611** (−2.27)
Contiguous	3.150*** (20.74)	3.092*** (19.43)
Initiator is a democracy	0.101 (0.77)	0.122 (0.93)
Target is a democracy	0.234* (1.75)	0.292** (2.19)
Joint democracy	−0.765*** (−3.85)	−0.767*** (−3.86)
Initiator is a major power	0.640*** (3.63)	0.678*** (3.85)
Target is a major power	0.775*** (3.22)	0.772*** (3.14)
Both major	−0.316 (−0.61)	−0.413 (−0.77)
Relative power of initiator	0.689*** (3.78)	0.687*** (3.77)
Trade depend. of initiator	0.839 (0.93)	1.035 (1.09)
Econ. growth of initiator	−0.452 (−1.31)	−0.885** (−2.37)
Foreign policy similarity	−0.958*** (−4.47)	−0.921*** (−4.33)
Allied	0.342** (2.48)	0.320** (2.34)
Peace years	−0.239*** (−12.69)	−0.246*** (−12.55)
Spline 1	2.031*** (7.15)	2.122*** (7.39)
Spline 2	−6.766*** (−5.26)	−7.207*** (−5.58)
Spline 3	−7.467 (−0.69)	−5.058 (−0.49)
Constant	−4.685*** (−19.94)	−4.604*** (−19.19)
Observations	543621	527214
Pseudo R^2	0.398	0.402
Estimation	Logit	Logit
Test	Wald	Wald
Chi-Squared	2866.2	2913.8
Log-likelihood	−3737.2	−3580.0

t statistics in parentheses; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Dispute initiations do not include joiners.

Table 5. Resource-based energy dependence and militarized interstate dispute initiation.

	(Model 3)	(Model 4)	(Model 5)	(Model 6)
Independent variables$_{(t-1)}$	Dispute initiation$_{(t)}$	Dispute initiation$_{(t)}$	Dispute initiation$_{(t)}$	Dispute initiation$_{(t)}$
Coal Depend. of initiator	−1.594 (−0.65)			
Oil Depend. of initiator		−0.708 (−0.87)		
Natural gas Dep. of initiator			−3.486* (−1.67)	
Electricity Dep. of initiator				−83.97 (−1.50)
Contiguous	2.997*** (18.64)	3.080*** (20.16)	3.142*** (20.78)	3.169*** (20.02)
Initiator is a democracy	0.0354 (0.25)	0.129 (0.94)	0.0991 (0.75)	0.0522 (0.37)
Target is a democracy	0.181 (1.22)	0.240* (1.76)	0.235* (1.75)	0.186 (1.26)
Joint democracy	−0.763*** (−3.45)	−0.800*** (−3.96)	−0.773*** (−3.88)	−0.852*** (−3.86)
Initiator is a major power	0.703*** (3.74)	0.622*** (3.57)	0.643*** (3.65)	0.840*** (4.50)
Target is a major power	0.860*** (3.54)	0.723*** (2.91)	0.808*** (3.36)	1.010*** (3.88)
Both Major	−0.273 (−0.49)	−0.237 (−0.46)	−0.335 (−0.64)	−0.604 (−1.07)
Relative power of initiator	0.747*** (3.85)	0.716*** (3.76)	0.705*** (3.88)	0.811*** (4.00)
Trade depend. of initiator	0.485 (0.59)	0.972 (1.04)	0.722 (0.81)	1.189 (1.15)
Econ. growth of initiator	−0.723* (−1.93)	−0.622* (−1.70)	−0.462 (−1.33)	−1.028*** (−2.60)
Foreign policy similarity	−1.020*** (−4.79)	−0.953*** (−4.42)	−0.946*** (−4.43)	−0.884*** (−3.86)
Allied	0.432*** (3.08)	0.319** (2.24)	0.351** (2.56)	0.342** (2.20)
Peace years	−0.226*** (−11.68)	−0.237*** (−12.26)	−0.239*** (−12.61)	−0.242*** (−11.91)
Spline 1	1.855*** (6.30)	1.980*** (6.82)	2.028*** (7.11)	2.038*** (6.69)
Spline 2	−6.314*** (−4.75)	−6.562*** (−5.01)	−6.749*** (−5.24)	−7.088*** (−5.24)
Spline 3	−5.659 (−0.57)	−7.667 (−0.71)	−7.545 (−0.70)	−1.408 (−0.16)
Constant	−4.632*** (−19.01)	−4.664*** (−19.04)	−4.699*** (−19.90)	−4.760*** (−18.74)
Observations	464148	496770	542482	540411
Pseudo R^2	0.385	0.391	0.398	0.401
Estimation	Logit	Logit	Logit	Logit
Test	Wald	Wald	Wald	Wald
Chi-Squared	2464.3	2721.7	2855.6	2567.9
Log-likelihood	−3337.3	−3609.4	−3731.9	−3336.4

t statistics in parentheses; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Dispute initiations do not include joiners.

exists, seems not to have a discernable effect on an importer state's propensity to use force against its exporters.[22]

These preliminary findings suggest that the relationship between energy flows and interstate conflict is not straightforward, and maybe conditional on resource type or technology. GERD enables the construction of other theoretically relevant energy variables to further parse out this relationship. Our dataset also facilitates the employment of alternative empirical specifications that could better reflect hypothesized relationships. Finally, given global efforts to move from hydrocarbons to other forms of energy carriers, further analyses on this topic would allow us to form evidence-based expectations on how the energy transition could reshape global geopolitics.

Conclusion

Although various international and national agencies collect and disseminate quality data on various aspects of energy production, consumption, and trade, international relations scholars do not currently have access to a dataset with wide spatiotemporal coverage for interstate energy flows. The lack of such a dataset has been constituting an important impediment for conducting systematic empirical analyses on how cross-border energy flows shape interstate relations and vice versa.

The Global Energy Relations Dataset (GERD), featured in this paper, aims to address this shortcoming by providing global dyadic energy data between the years 1978 and 2014. Compiling various monadic and dyadic data from major energy data providers, GERD offers various advantages. The energy trade figures are broken down by sources, i.e., coal, oil, natural gas, and electricity, and standardized over megajoules. The conversion rates for energy resources to megajoules have been done at the most granular level possible (e.g., lignite vs. coke, Russian gas vs. Norwegian gas) as data would allow.

A cursory overview of data suggests energy relations can significantly vary between states and over time. The possibility to correlate this variance with various political and economic variables opens up a multitude of avenues of research. Initial analyses suggest that higher levels of energy dependence prevent the occurrence of militarized interstate disputes (Lee and Mitchell 2019; Gōkçe, Hatipoglu, and Soytas 2021) and make energy trading states exhibit similar preferences in foreign policy (Gökçe 2019). Future analyses could also look at how energy relations affect the incidence,

[22]These preliminary analyses are certainly not sufficient to conclude oil dependence has no effect on the probability of a MID onset in a dyad. The coefficient in Model 3 may simply be the average of two separate worlds, in one of which oil pacifies relations, and, in the other, oil dependence makes importers more belligerent. Further theory-driven research is needed to parse out how energy relations exactly shape interstate relations.

duration, and termination of other political events and vice versa, such as economic sanctions and trade disputes.

GERD can improve on several dimensions. A Graphical User Interface (GUI) is under development for easier retrieval of data and to ensure more effective reach to non-academic users.[23] Researchers are encouraged to address missing data issues considering their research question. The next version of the dataset will utilize national-level renewable data from novel sources, including national statistical accounts, to supplement that of the IEA. Nonetheless, we believe the current structure of the dataset carries sufficient construct validity.

The global energy transition may jeopardize this validity in the medium term, and hence shape the evolution of GERD. For instance, the establishment of a global ultra-high-voltage grid may make the instantaneous transfer of the considerable amount of electrical energy across countries (and even continents) possible, making use of daytime and seasonal differences around the globe (Huang et al. 2009). Such a scheme would involve the instantaneous transfer of electricity between a buyer and a seller where the electrons travel across a few sovereign states. Accessing and compiling such global-level data on electricity trade and merging it to our existing dyadic framework would pose various theoretical and practical challenges. The increasing salience of rare earth minerals in the production of renewable energy points to another emerging topic that has not been captured by GERD (see, for instance, Bazilian 2018). Occasional bottlenecks in the production and global supply of these materials have already caused geopolitical tensions, such as the 2010 crisis between China and Japan (Gholz 2014). Consequently, future versions of GERD will have to invest more in disaggregating types of renewable energy relayed from one country to the other, and possibly include flows of energy-related materials other than primary energy resources to reflect the nature of energy relations between two states.

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[23]See https://apps.kapsarc.org/kgerd/home?fc=SAU&tc=&c= for the alpha version of this GUI.

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