Crude oil, international trade and political stability: Do network relations matter?

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Abstract

Starting from the estimate and description of the crude oil international network (155 countries) over the period 1995-2019, our work sheds new light on the relationship between crude oil and political stability. Our fundamental assumption is that oil dependence can determine political instability. Anyway, a country can rely on crude oil from two point of views: crude oil can represent the main source of revenue for some countries (economic dependence), while other countries can cover their energy needs mainly from oil, becoming indirectly exposed to the instability of oil-exporting countries (energy dependence). Exploiting the concepts of out-degree and in-degree centrality and using the simultaneous quantile regressions approach, we show that both economic and energy dependence on oil can represent a threat to internal stability. This outcome not only seems to corroborate the resource curse hypothesis in relation to oil-exporting countries, but also involves oil-importing countries. The latter import political instability together with oil, especially when their energy needs are mainly covered by crude oil.

Keywords: Crude oil; Network analysis; Political instability; International trade; Quantile regression

JEL Classification: D85; F14; Q34; C21

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1. Introduction

The debate on the macroeconomic impacts – especially economic growth – of resource endowments is still open, with some arguing that resource-rich countries have slower growth rates compared to resource-poor countries (i.e., the resource curse hypothesis), and others claiming that resource abundance enhances GDP growth (i.e., the theory of the rentier state). Previous studies (e.g., Tornell and Lane, 1999; Mehlum et al., 2006a) have highlighted the importance of institutional quality in turning the resource curse into a blessing, providing different explanations for their mediating role. Some studies (e.g., Ades and Tella, 1999; Sala-i-Martin and Subramanian, 2003) consider corruption and rent-seeking behaviours that emerge after the discovery of a new deposit of natural resources to be the main responsible of sluggish growth rates. Others (e.g., Niknamian, 2019; Wang et al., 2021a) claim that good institutions are essential to help resource rents propagate to the business sector and develop the financial system. However, as pointed out by Mehlum et al. (2006b), institutional quality can be altered by resource endowments: in this case, instead of mitigating the resource curse, institutions can become an additional source of resource curse themselves.

In this paper, we focus on institutional aspects related to political stability. In particular, we expect that oil-rich countries that are central in the oil export network suffer greater risk of political instability. In addition, the interconnectedness of the globalised economies extends the risk of political instability also to oil-importing countries, which are indirectly exposed to the instability of countries they import oil from. Hence, the aim of our paper is to disentangle the mechanisms that make oil dependence a factor enhancing political instability in both exporting and importing countries. In doing so, we focus on oil trade network centrality, in terms of both exports and imports, and complement it with two distinct measures of oil dependence, namely economic and energy dependence. Accordingly, we distinguish between political instability induced by the availability of oil within a country's territory and imported political instability.

The rest of the paper is structured as follows. Section 2 reviews the literature on natural resources and political stability and outlines our research hypotheses. Section 3 describes the panel database, the oil trade network, and the econometric modelling framework. Section 4 presents main results and Section 5 concludes.

2. Setting the issue

2.1 An overview of the literature

According to Max Weber's thought, the concept of political stability is essentially associated with the legitimation of a government to use physical force, providing basic services, and enforcing laws;

otherwise, political instability emerges, determining the failure of the state (Mommsen, 1992). From an empirical point of view, the latter situation is described as the tendency of a government to fall – either because of internal conflicts or rivalry among political parties.

Political instability has often been studied in relation to economic growth as two deeply interconnected phenomena. In their seminal work, Alesina et al. (1996) analyse both sides of this relationship: on the one hand, politically unstable countries are characterized by lower rates of growth; on the other hand, the reverse causality does not always hold, especially for all those government changes other than coups. Focusing on the first nexus, Uddin et al. (2017) find that the positive effect of political stability on economic growth is particularly strong for developing countries. A reduction in private investments and consumptions is often seen as the first consequence of an unstable political environment, while Aisen and Veiga (2013) identify total factor productivity as the main transmission channel – together with physical and human capital accumulation – from political instability to economic growth.

Political instability and economic growth have also been analysed in relation to another important concept, that is the country's initial endowment of a natural resource. Natural resource abundance has been primarily deepened in relation to economic growth. In this regard, Sachs and Warner's (1995) influential study represents one of the first attempts in this respect: economies with abundant natural resources tend to experience lower economic growth compared to economies with scarcer endowments. This has been also called the resource curse hypothesis, which – from a theoretical point of view – has been justified in several ways.[1] In terms of political economy, according to Lane and Tornell (1995), resource-rich economies are more prone to rent-seeking behaviours than resource-poor economies; competing factions tend to struggle in order to grab natural resource rents, inefficiently exhausting the public good. Exploring this idea further, Hodler (2006) deepens the reasons why natural resources seem to be a curse in some countries but a blessing for others. According to the author, natural resources tend to be a burden in fractionalised countries; on the contrary, when a country is characterised by few rivalling groups, positive income effect more than offsets the lower costs consequent to fighting activities.

Another significant economic argument considers manufacturing – unlike natural-resource production – as a driver for a more complex division of labour and then to a higher standard of living. Matsuyama (1992) and the Dutch disease model represent two important formalisations of this idea. In the first framework, there exist two sectors, agriculture and manufacturing; the latter is characterised by learning-by-doing, which is proportional to total sectoral production. If a country

[1] Resource curse generally refers to the adverse effects of a country's natural resource wealth on its economic, social, or political well-being. This term has been first used in print by Auty (1993).

mainly bases its production on agriculture, it will experience lower growth rates, by reducing the learning-induced growth of manufacturing. This framework is particularly valid when studying labour-intensive production of natural resources. Nevertheless, it tends to be less accurate for those resources whose exploitation is more capital-intensive, as in the case of oil production. In these cases, resources – in terms of labour – are not taken away from manufacturing and the learning-by-doing effect will not be reduced. The Dutch disease model can be used to contextualise and extend Matsuyama's framework in a more general setting. In this case, the sectors are three: a non-tradable sector – identified with services – and two tradable sectors (a booming sector and a lagging one). Traditionally, the booming sector is of an extractive kind, while the manufacturing sector is placed under pressure. When natural resources are plentiful, tradable production is focused on natural resources rather than manufacturing, and capital and labour that otherwise might be employed in manufacturing are pulled into services. A central feature is the distinction between two effects of a potential resource boom, namely the resource movement effect and the spending effect. The first effect shifts labour from the lagging sector to the booming one, determining the so-called direct deindustrialisation; however, this effect tends to be negligible when the booming sector is highly capital-intensive, as in the case of petroleum extraction. The second effect is the result of an extra-revenue induced by the resource boom, leading to an increase of labour in the non-tradable sector at the expense of the lagging one. This shift is also called indirect deindustrialisation. In this context, if manufacturing is characterised by externalities in production, as in the Matsuyama's model, then the contraction of the manufacturing sector caused by resource boom can lead to a decline in growth. In these cases, the natural resource boom or the significant initial endowment can represent a real disease and a source of chronic slow growth.

In any case, empirical evidence in favour of a causal link between natural resource abundance and economic growth, as well as its sign, is not unequivocal. According to Alexeev and Conrad (2009), for example, oil and mineral resources have increased rather than discouraged long-term growth; the reverse causal relationship that emerges from the previous literature comes from a misinterpretation of the available data, which do not consider the different temporal effect of exploiting a resource – from discovery to commercial exploration and through depletion – on economic growth.[2]

The resource curse hypothesis – and, more generally, the abundance in natural resources, mainly oil – has been also deepened in relation to other aspects, that is corruption, authoritarianism, and civil wars. Put differently, natural resources are seen as fundamental drivers for armed conflicts and

[2] In their empirical analysis, researchers have considered growth rates starting from 1965 or 1970, but most oil exporters began commercial oil exploitation long before 1950. In this context, the real impact of mineral resources on economic growth can be hidden by the availability of reliable data. Typically, the highest growth rates are in fact experienced in the early stages of extraction while economic growth tends to slow as oil deposits mature.

indirect economic and institutional causes of violence (Ross, 2004, 2006). Influential research by Collier and Hoeffler (2004) shows that countries whose income mostly derives from the exportation of primary commodities – both agricultural and natural resources – are highly predisposed to civil violence. At this regard, Humphreys (2005) summarises the six main causal mechanisms that can lead to the outbreak of civil wars. The first two mechanisms are related to the notion of greed: domestic groups (i) or foreign countries (ii) are encouraged to start or continue conflicts in order to gain control over profitable resources. (iii) Grievances may represent another causal mechanism: countries that rely on natural resources tend to be vulnerable to trade shocks, determining discontent among groups hit by those shocks. (iv) Natural resources could also be an opportunity rather a motive of civil wars, financing rebellions started for other reasons and increasing their chances of success. (v) Countries that depend on natural resources rather than taxation tend to have less power over their citizens and weakened incentives to create strong bureaucratic institutions. The subsequent low quality of institutions makes civil conflicts more likely. (vi) As internal trade stimulates social cohesion, countries driven by foreign trade in natural resources are more vulnerable to higher conflict risks.

However, the general debate seems to have mistreated a critical differentiation between country's dependence on and its abundance of resources: on the one hand, the first notion implies that rents from natural resources represent the most important source of income relative to other value-adding activities; on the other hand, the second concept directly relates to the absolute amount of resource rents available in per capita terms. From this point of view, dependence may effectively represent the main cause of conflicts. In this context, a relevant theoretical challenge to the resource curse hypothesis and its economic and social consequences comes from the theory of the rentier state, which was firstly developed in relation to Middle Eastern oil-producing states (Madhavy, 1970). The rentier state tends to be characterised by economic stagnation, corruption, and authoritarianism, but it is also able to use its economic resources to buy off opposition or suppress armed rebellion: using a sample of oil-exporting countries, Basedau and Lay (2009) find evidence that countries rich in oil per capita manage to maintain peace by a combination of large-scale distribution, high spending on the security apparatus, protection by outsiders and more favourable state institutions.

Currently, the new consensus appearing in the literature interprets resource dependence neither as a curse nor as a blessing: all seems to depend on the quality of institutions of a certain country. This results holds in relation to both economic growth performances and social issues, such as corruption: on the one side, countries with high quality institutions can make a natural resource a blessing, while countries with low quality institutions a curse for economic growth (Antonakakis et al., 2017); on the other side, resource rents can lead to an increase in corruption if the quality of the democratic institutions is relatively poor, due to rent-seeking behaviours (Bhattacharyya and Hodler, 2010). In

any case, cross-country evidence also supports the idea that oil hampers democracy and degrades the quality of institutions (Busse and Gröning, 2013). This can be interpreted as a further aspect of the resource curse hypothesis, which we have previously analysed in relation to economic growth. Besides rent-seeking behaviours among elected representatives, this negative effect could derive from an inadequate level of taxation – natural-resource revenues tend to substitute for non-resource revenues (James, 2015) – which is seen as necessary for democratic representation. Focusing the attention only on petroleum, there is increasing empirical evidence that it tends to make authoritarian regimes more durable (Andersen and Ross, 2014), to undermine the stability of democratic regimes (Jensen and Wantchekon, 2004), to increase corruption and to help trigger violent conflict in low- and middle-income countries (Ross, 2015).

2.2 Research hypotheses

As previously highlighted, the debate about the nexus between oil and political stability is still open, as some countries have benefitted from their richness in oilfields, gaining political stability and economic growth, while in others oil abundance has turned into a curse, provoking civil conflicts, political turmoil, and adverse economic outcomes.

In our context, utmost importance has been given to the understanding of the mechanisms that have led to these opposite situations. Countries in which the oil sector is the engine of the economy are usually economically dependent on oil revenues to finance their government spending and grow (Hamdi and Sbia, 2013). In line with the Dutch disease theory, the discovery of a deposit of natural resources, such as oil, has the effect of crowding out the manufacturing sector in favour of the extractive sector. In particular, oil exports become the main source of national income, but this have two main drawbacks: i) to increase real exchange rate, contracting exports in the manufacturing sector (e.g., Torvik, 2001; Rajan and Subramanian, 2011; Van der Ploeg and Venables, 2013); ii) to make a that country heavily exposed to oil price volatility (e.g., Mehrara, 2008; Korhonen and Ledyaeva, 2010; Chen and Hsu, 2012). This, together with potential issues arising from the allocation of oil revenues, can have severe consequences in terms of political stability.

In our analysis, we propose that being central in the crude oil export network and maintaining this position over time can compromise a country's political stability, even more in structurally unstable countries. Accordingly, we formulate our first research hypothesis:

- *H1: a higher out-degree centrality within the crude oil network reduces political stability, especially in structurally unstable countries.*

Given the strong economic and geopolitical interconnections of our globalised economy, local political conditions can have repercussions on very distant countries through bilateral trade flows.

This is especially the case of oil, whose availability in the underground is highly localized and concentrated in specific places, and whose consumption still constitutes the largest share of the energy mix for many countries (BP, 2020). This makes these countries increasingly dependent on imports. As a consequence, political instability and tensions internal to oil-producing countries can compromise oil provision or increase prices in oil importing countries, resulting in imported political instability. Accordingly, we formulate our second research hypothesis:

- *H2: a higher in-degree centrality within the crude oil network increases imported political instability in more stable and oil-dependent countries.*

3. Data and methodology

3.1 The database

Our analysis is based on a panel of 155 countries over the period 1995-2019. To test our research hypotheses, the dependent variable *pol_stab*, gathered from the Worldwide Governance Indicators by World Bank, measures the perception of the likelihood of political instability and political violence, including terrorism. It assumes both negative and positive values, with higher values corresponding to better outcomes, and has the advantage to cover a long-time span and be comparable across different countries. In addition, to check the robustness of our empirical estimates, we also gather the State Fragility Index (*sfi*) from the Center for Systemic Peace (Marshall and Elzinga-Marshall, 2018), as an alternative dependent variable. This index accounts for both effectiveness and legitimacy in four key performance dimensions, namely security, political, economic and social and assigns the final value combining scores from these eight indicators. In this case, higher values correspond to worse outcomes.

Grounding on the original data on bilateral crude oil trade flows supplied by the Observatory for Economic Complexity (OEC), we calculate our two key independent variables, namely *out_degree* and *in_degree*. The formers represent a country's position of centrality within the oil export network, while the latter accounts for a country's position of centrality within the oil import network. We do not linger over these concepts here, as they are the focus of the next two paragraphs. However, for the purpose of our empirical analysis, we employ a relative measure of out-degree and in-degree centralities, by normalizing the values with respect to their yearly total, obtaining the variables *out_deg_n* and *in_deg_n*.

Control variables have been identified following prior empirical studies and can be classified into three groups: i) measures of oil dependence; ii) socio-economic factors affecting political stability; iii) political-institutional characteristics. In the first group, we account for countries' dependence on

oil as either a valuable resource (economic dependence) or the main energy source (energy dependence). In most oil-rich countries, revenues from oil exploitation and exports represent the engine of the economy, making these countries economically dependent on oil (e.g., Ogunleye, 2008; Hamdi and Sbia, 2013). Hence, we measure economic dependence as the share of GDP captured by oil rents (*oil_rents*). On the other hand, oil-poor countries can be energy dependent on oil if this represents the main energy source in their energy mix. In this case, energy dependence on oil can expose these countries to hardly controllable geopolitical turmoil that can threaten their internal political and economic stability (Aguiar-Conraria and Wen, 2012; Ji et al., 2019; Wang et al., 2021b). To control for these factors, we include in our dataset a variable representing the share of oil consumption on total primary energy consumption (*oil_share*); then, we interact this variable with a country's in-degree centrality to account for energy dependence on oil (*energy_dep*).

In the second group, we include gross domestic product per capita (*GDP_pc*) and the Gini index (*gini*) to account for income-related and distributive factors that can influence political stability. In addition to the Gini index, we also include a measure of ethnic (horizontal) inequality, which often enhances political instability and leads to the outbreak of armed conflicts (Caprioli and Trumbore, 2003; Østby, 2008; Caselli and Coleman, 2013). Starting from information on the size and status of ethnic groups in each country, provided by the Ethnic Power Relations (EPR) database by Vogt et al. (2015), we compute a measure of the cumulative discriminated size of ethnic groups with respect to total population in a given country and year (*discr*). We also include the average oil price (*oil_price*) to control for economic shocks that can affect, although in different ways, living conditions in both oil exporting and importing countries.

Lastly, among political-institutional characteristics influencing political stability, we include the type of regime and countries' legal origins. From the Center for Systemic Peace, we collect data on institutionalized democracies, which are defined as such if three elements are present: institutions that guarantee citizens to express their political preference; institutionalized constraints on the exercise of power; guaranteeing civil liberties. The resulting variable *democ* assumes values from 0 to 10, with higher values indicating more democratic regimes[3]. Further, following the insights on colonial institutional inheritance provided by Acemoglu et al. (2001), we include countries' legal origins to control for historical trends in political stability. In particular, we include three dummy variables from La Porta et al. (1999), which capture differences in national commercial legal traditions, divided into common law (*legor_uk*), French civil law (*legor_fr*) and other legal traditions (*legor_other*), which

[3] The Center for Systemic Peace also assigns the special values of -66 in the case of "foreign interruption", which is treated as "system missing", -77 in the case of "interregnum" and the value of -88 in the case of a regime transition.

include German civil law, Scandinavian law, and socialist law. Table 1 reports the acronyms for all variables used in the empirical analysis, the original sources, and main statistics.

Table 1 – Descriptive statistics and data sources

Variable	Obs	Mean	Std. Dev.	Min	Max	Source
pol_stab_i	3,875	-0.18111	0.961361	-3.1808	1.760102	WGI - World Bank
out_degree	3,875	5.06E+09	1.81E+10	0	2.66E+11	Authors' elaboration on OEC
out_deg_n	3,875	0.006452	0.019456	0	0.189357	Authors' elaboration on OEC
in_degree	3,875	4.84E+09	2.01E+10	0	3.31E+11	Authors' elaboration on OEC
in_deg_n	3,875	0.006452	0.023323	0	0.262389	Authors' elaboration on OEC
GDP_pc	3,863	10832.42	17224.77	102.598	154919.2	WDI - World Bank
democ	3,710	2.909434	14.96603	-88	10	Center for Systemic Peace
oil_price	3,875	54.64358	29.73718	13.98125	104.6292	Investing.com
Gini	3,875	0.57104	0.085522	0.337196	0.841389	WID
Discr	3,875	0.028828	0.090507	0	0.84	EPR
legor_uk	3,875	0.264516	0.441132	0	1	La Porta et al. (1999)
legor_fr	3,875	0.458065	0.498303	0	1	La Porta et al. (1999)
legor_other	3,875	0.270968	0.444517	0	1	La Porta et al. (1999)
oil_rents	3,825	4.267598	10.18071	0	66.71276	World Bank
oil_share	1,750	42.95966	18.05516	5.053	99.407	BP Statistical Review of World Energy
energy_dep	1,750	3.82E+11	1.05E+12	0	1.29E+13	Authors' elaboration on OEC and BP
Sfi	3,709	9.004044	6.509576	0	25	Center for Systemic Peace

3.2 The crude oil trade network

In mathematics, a graph is a structure made of vertices and edges; the vertices are also called nodes (or points) and are connected to each other by an edge (or link). Formally, it is possible to define an undirected graph as a pair $G = (V, E)$; V is the set of vertices and E is the set of edges, which are unordered pairs of elements of V. Mathematically, given the set of vertices V, we can define E in the following way:

$$E = \{\{x, y\} | x, y \in V, x \neq y\} \tag{1}$$

The formal definition of a directed graph is similar, the only difference is that the set E contains ordered pairs of elements of V. Graphically, this translates into fixing a direction of travel of the connections and therefore of arrows from one node to another. Mathematically, this means working with the Cartesian product $V^2 = V \times V$, i.e.

$$E = \{(x, y) \in V^2 | \, x \neq y\} \tag{3}$$

Network theory is a part of graph theory (Otte and Rousseau, 2002): a network can be defined as a graph where vertices and edges have attributes (i.e., names, money…). In a way, without these

attributes, a network (i.e., a graph) becomes a hypothetical structure that does not exist in the real world. Edges can have weights – numbers that in some applications may be a measure of the length of a route or the capacity of a line. In this case, we will refer to these as weighted networks or graphs. Similarly, we will talk about undirected network and directed network. For this reason, we will use a terminology closer to the network theory by calling the vertices, nodes, and the edges, links.

In this paper, we model the trade concerning crude oil through a weighted directed network. A graph – and then a network – can be represented by a particular square matrix, the adjacency matrix. In place (i, j) of the matrix there is a non-zero number if and only if there is a link in the graph that goes from the node i to the node j (hence this number will be the weight of the link), otherwise there is a 0. Formally, we are talking about the $n \times n$ matrix A indexed by V, whose (i, j)-entry for a directed graph is defined as

$$A_{ij} = \begin{cases} w_{ij} & if\ (i,j) \in E \\ 0 & if\ (i,j) \notin E \end{cases} \tag{4}$$

where w_{ij} is the weight of link (i, j). With each link $l = (i, j)$ of E let there be associated a real number $w(l) = w_{ij}$, called its weight. We assume that each node of the directed network represents a country and the directed link between two trading countries represents a flow of money between them; the outward arrow indicates the exports, the incoming arrow indicates the imports, the weight indicates the amount of exports or imports in euros. This happens according to a temporal (dynamical) mechanism, which modifies the numerical attributes of links between countries (i.e., the flow of money between them). More in details, if country i imports some good from country j during the year t, then a link from i to j is drawn in the t-th snapshot of the graph, corresponding to a non-zero entry in the corresponding adjacency matrix. In our problem, the adjacency matrix has 0s on the diagonal because countries cannot export to/import from themselves. From now on we suppose that all graphs and measures are fixed at time t and, since the purpose of this article is to show their trend over time, in the results section we will specify in which instant in time (i.e., year) they have been calculated.

Let us now introduce the centrality measures that we will use to identify the most influential countries in the crude oil trade network. The centrality measures are indices that allow us to understand what characterizes an important node and then an important country. In such a description, they assign numbers and rankings to countries corresponding to their position in the crude oil trade network. From a conceptual point of view, the simplest one is the weighted degree centrality, which is related to the number of links entering or exiting a certain node. If we look at the outgoing links, then we are talking about the weighted out-degree centrality, representing the export side of a country. If n denotes the number of countries in our problem, the weighted out-degree centrality of country/node i can be defined as follows (Wasserman and Faust K, 1994):

$$od_i = \sum_{j=1}^{n} w_{ij} = \sum_{j=1}^{n} A_{ij} \tag{6}$$

for $i = 1, 2, \cdots, n$ (i.e., it can be seen as a sum by columns of the entries of A). The weighted out-degree centrality captures the outreach of a country to the community. A high weighted out-degree centrality value indicates that a country i exports a lot, aiming to reach all other countries with a certain pervasiveness (all are practically connected with everyone, but the network is with weight and the weight in our example tells how pervasive the influence of i is). The weighted out-degree centrality, then, captures the level of engagement a country i initiates with members of the community. If we look at the incoming links, then we are talking about weighted in-degree centrality, the import side of a country. Formally, the weighted in-degree centrality of country/node j can be defined as follows (Wasserman and Faust K, 1994):

$$id_j = \sum_{i=1}^{n} w_{ij} = \sum_{i=1}^{n} A_{ij} \tag{7}$$

for $j = 1, 2, \cdots, n$ (i.e., it can be seen as a sum by rows of the entries of A). The weighted in-degree centrality measures the number of links others have initiated with a particular country. Countries with high weighted in-degree centrality gain attention to their markets among the countries who participate in the exchange. Countries' weighted in-degree centrality, thus, captures the community's engagement with them. Those with high weighted in-degree centrality scores can be thought as market hubs since others have exported in them.

3.3 Descriptive network analysis

Crude oil plays a fundamental role in the world energy market. In 2019, crude oil constituted 33.1% of the total primary energy supply, which is greater than the share contributed by any other energy source (BP, 2020). The uneven distribution of crude oil production and consumption characterises the international crude oil trade network. In other words, global oil reserves, its production, and consumption are dislocated in various proportions among different areas, determining a relevant mismatch between supply and demand.[4]

[4] Wu and Chen (2019) globally examine the use of crude oil, conducting an input-output analysis. Crude oil represents an essential commodity since its use is potentially twofold: on the one hand, crude oil is directly used in terms of consumption of oil products; on the other hand, it is indirectly used in relation to the consumption of other goods or services that need oil inputs in their production process. According to their results, the utility of oil resources can be redistributed among regions due to the high levels of trade in the context of globalization: about half of the global crude oil exploited is embodied in net trade. This confirms the significant divergence between exploiting countries (i.e., the OPEC) and consuming countries (i.e., China).

Taking into consideration the top five crude oil exporters and importers in our network analysis, the United States are the only country that in 2019 appear in both sides of the trade network flows (Table 1). With its exception, four countries provide more than 40% of total export centrality (41.6%). Moreover, the case of the United States represents a recent consequence of the introduction of new mining technologies – like hydraulic fracturing (fracking) – that has significantly increased crude oil production in the last few years. This is evident from our data as, in 1995, the USA occupied the 45th position out of 200 countries in the crude oil export network. In 1995, around 30% of overall exports were led by just three countries (Saudi Arabia, Russia, and Canada). On the import side, the network analysis reveals two diverging trends: on the one hand, China and India have known a remarkable increase of their share on world import, making the first country the largest oil importer (in 2019, 21.2%); on the other hand, the United States have lost their primacy, halving the overall amount of oil imported over twenty-five years (in 2019, 12.8%).

Table 2 – Relative values

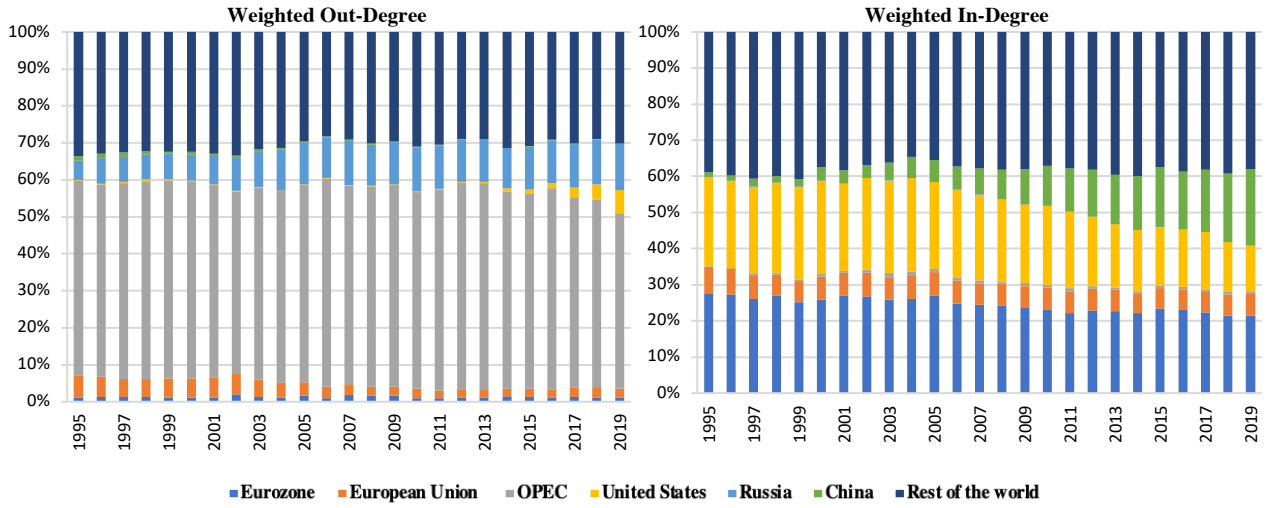
Weighted Out-Degree			**Weighted In-Degree**		
Top five crude oil exporters			*Top five crude oil importers*		
	1995	**2019**		**1995**	**2019**
Saudi Arabia	17.7%	14.7%	**China**	1.3%	21.2%
Russia	5.2%	12.5%	**United States**	24.8%	12.8%
Iraq	0.2%	7.5%	**India**	1.7%	9.7%
Canada	3.9%	6.9%	**Korea, Rep.**	5.3%	7.0%
United States	0.0%	6.3%	**Japan**	15.0%	6.7%
	27.1%	47.9%		48.2%	57.3%

Source: elaborations on *OEC- The Observatory of Economic Complexity* data

In order to show the main features of the international crude oil network in dynamic term from 1995 to 2019 (weighted out-degree and in-degree), we have grouped countries into seven clusters: the Eurozone, the European Union and the Organization of the Petroleum Exporting Countries (OPEC) as a whole, the United States, Russia, China and the 'rest of the world', which includes all remaining countries (Figure 1). On the export side (weighted out-degree), there emerge two different patterns: on the one hand, we observe an overall decreasing trend in relation to the individual share of oil exports on total exports from the European Union (-3.5 p.p.), OPEC (-5.4% p.p.), China (-1.2 p.p.) and the rest of the world (-3.4 p.p.); on the other hand, this decrease is offset by the significant increase in crude oil exports of Russia (7.3 p.p.) and the United States (6.3 p.p.). On the import side (weighted in-degree), it is possible to examine in historical terms what has been previously stressed,

that is the significant growth of the Chinese economy (19.9 p.p.), whose share of imports has replaced that of the United States (-12 p.p.) and of the Eurozone (-6.2 p.p.).[5]

Figure 1 – Relative values



Note: the European Union includes the United Kingdom (28 countries) – its overall value derives from the sum of the columns 'Eurozone' (19 countries) and 'European Union'. Currently, the OPEC comprises a total of 13 member countries: Algeria, Angola, Congo, Equatorial Guinea, Gabon, Iran, Iraq, Kuwait, Libya, Nigeria, Saudi Arabia, United Arab Emirates and Venezuela.
Source: elaborations on *OEC- The Observatory of Economic Complexity* data

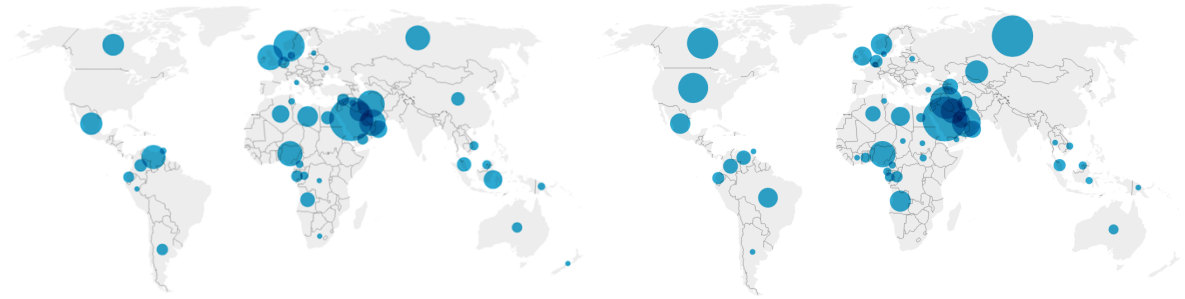
The previous trends can be also analysed by directly comparing 1995 with 2019 and showing the relative intensity of the out-degree and in-degree centralities worldwide (Figure 2). In relation to the first kind of centrality (a), the significant increase in the contribution of the United States and Russia to global crude oil exports is graphically confirmed. Iraq, as part of the OPEC, is the country which has experienced the most important increase of its influence over time. The progressive reduction of European Union exports mainly comes from a lower share of the United Kingdom contribution (-3.2 p.p.). In the European context, Norway has faced a significant decrease of its relative importance within international trade (-3.2 p.p.). The second kind of centrality (b) highlights the remarkable growth of Asian countries in terms of crude oil imports. The role of China has been already noted: more than one-fifth of the world's crude oil imports comes from this country. India and South Korea have also known a relevant growth between 1995 and 2019. United States and Japan have experienced the largest decrease in global crude oil imports but this diminution in relation to the first country has mainly resulted from the simultaneous increase in domestic production.

[5] China has become increasingly dependent on oil imports due to a stagnating domestic production, a high overall growth, and the goal to switch from coal to improve environmental quality. See He and Guo (2021) to deepen the pattern of Chinese crude oil trade relationships with other countries and factors that have influenced these relationships. In particular, China has become increasingly important, playing a role as a transit hub of crude oil: approximately one third of imported oil in China is re-exported through producing commodities and services for satisfying final consumption outside China (Zhang et al., 2020).

Figure 2 – Crude oil – Weighted Out-Degree – Relative values

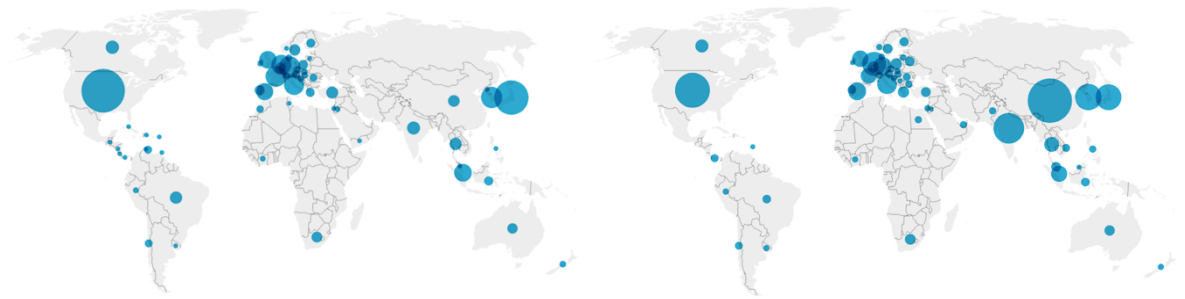
(a) Weighted Out-Degree

1995 **2019**



(b) Weighted In-Degree

1995 **2019**

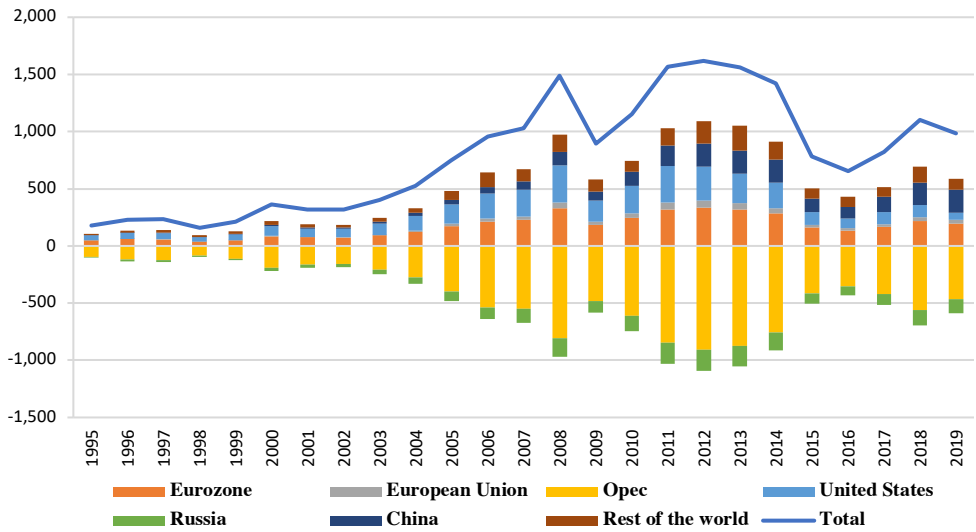


Source: elaborations on *OEC- The Observatory of Economic Complexity* data

Up to this point, we have analysed the two sides of trade separately. Taking into consideration the previous categorization among groups of countries, Figure 3 shows the pattern of their net imports in terms of value. At this regard, some aspects can be highlighted. First, on average, more than 90% of European Union net imports comes from the Eurozone. Secondly, Russia and the OPEC represent the two main net exporters. Russia has progressively increased its net exports: in 1995, 91% of net exports was covered by the OPEC, while in 2019 this share has been reduced to 79%. Thirdly, OPEC's net exports have known a rapid growth since the early 2000s. The subsequent contraction following the financial crisis of 2008 lasts a couple of years, while their value tends to decrease over the last few years. Actually, OPEC's net exports tend to follow the overall trade values, whose evolution can be in turn explained by the two sides of the crude oil trade in terms of value: on the one hand, oil price movements; on the other hand, changes in total trade volume (Figure 4). From 1995 to 2008, the total traded volume and the average price are characterised by an increasing path; in the aftermath of the global financial crisis of 2008, the first downturn of the overall trade values is the consequence of a

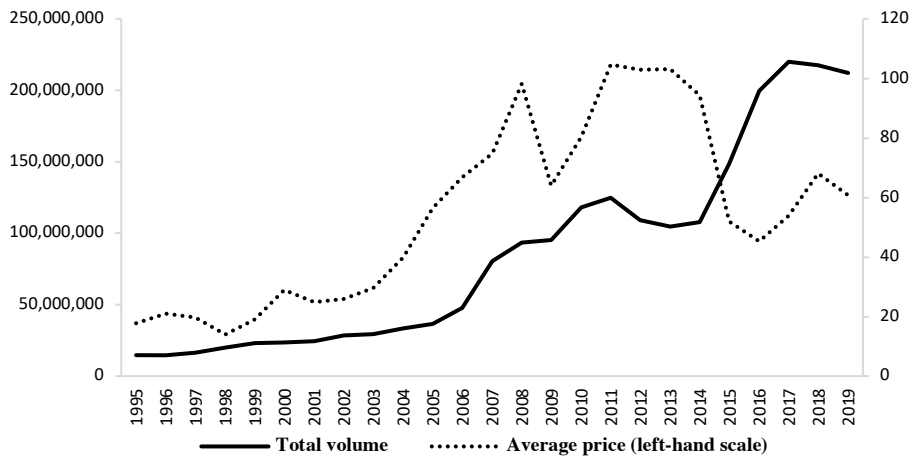
sharp price reduction; from 2013 onwards, an even more pronounced price decline has been partially compensated by a significant growth of global crude oil demand.[6,7]

Figure 3 – Net imports and overall trade – Crude oil – Billion dollars



Note: the columns represent the net import value position of seven groups of countries – as before, the European Union includes the United Kingdom (28 countries), and its overall value derives from the sum of the columns 'Eurozone' (19 countries) and 'European Union'. If the value is positive (negative), a country is importing (exporting) crude oil in net terms. The sum between the positive columns and the negative ones is equal to zero.
The blue line shows the overall trade values of crude oil.
Source: elaborations on *OEC- The Observatory of Economic Complexity* data

Figure 4 – WTI and Brent Crude Oil futures: Total volume and average price



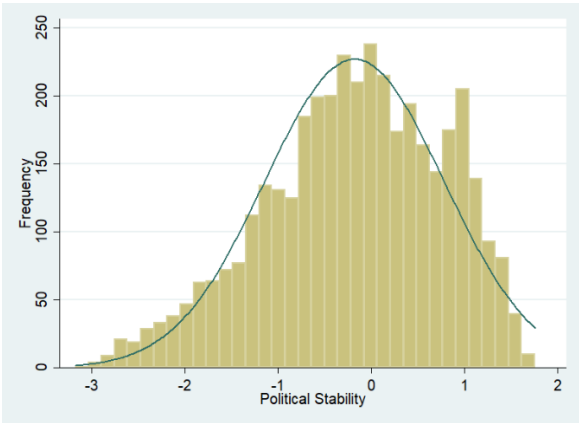
Note: WTI and Brent are two of the most traded types of crude oil: the first one is extracted from oil fields in the United States, while the second one from oil fields in the North Sea (Europe). Usually, WTI (or West Texas Intermediate) refers to the price of the New York Mercantile Exchange (NYMEX) WTI Crude Oil futures contract, and Brent Crude to the price of the ICE Brent Crude Oil futures contract. We have taken into consideration the overall volume and the average price of the two markets.
Source: elaborations on *Investing* data

[6] Oil prices rise in the post-2004 period when Asian economies start to growth faster than expected with an available supply which at first remained stable (Hamilton, 2009).
[7] From a theoretical point of view, oil price movements are important since they tend to shift wealth between oil-importing and oil-exporting countries (Huntington, 2015).

3.4 Simultaneous-quantile regressions

When the dependent variable is not normally distributed or is skewed with some outliers, the simultaneous quantile regressions approach, firstly theorised by Koenker and Bassett (1978), provides a useful tool to address these issues. When analysing social phenomena, heavily skewed distributions are more common than normal distributions (Koenker and Hallock, 2001), thus assumptions required by conditional-mean models are often violated. As shown in Figure 5, this is the case of our dependent variable, political stability, which is negatively skewed. The presence of heavy tails suggests the potential presence of substantial differences in the effects of the independent variables on political stability.

Figure 5 – Histograms and kernel density for political stability



The main advantage of quantile regression is that it allows to estimate the heterogeneous effects on the entire conditional distribution of the dependent variable (Coad and Rao, 2006). In this study, we estimate simultaneously the effects on the 25th, 50th and 75th quantiles of our dependent variable on a scale from 0 to 100. Within the strand of literature examining the resource curse hypothesis, Gerelmaa and Kotani (2016) already had this intuition, testing the effects of the Dutch disease on different quantiles (25th, 50th and 75th) of economic growth in a large panel of countries. They find that the effects on growth differ when considering different quantiles and in different time periods. The same approach is also employed by Wang et al. (2021a) to test the mediating role of political stability and fiscal decentralization in turning the resource curse into a blessing. To our knowledge, this is the first study in which this technique is employed to study the effects on political stability. To test formally our two research hypotheses, we estimate the following two equations:

$$Q(Pol_stab_{i,t}) = \beta_0 + \beta_1 out_degree_{i,t-1} + \beta_2 X_{i,t-1}^{OD} + \beta_3 X_{i,t-1}^{SE} + \beta_4 X_{i,t-1}^{PI} + \varepsilon_{i,t} \quad (8)$$

$$Q(Pol_stab_{i,t}) = \gamma_0 + \gamma_1 in_degree_{i,t-1} + \gamma_2 X_{i,t-1}^{OD} + \gamma_3 X_{i,t-1}^{SE} + \gamma_4 X_{i,t-1}^{PI} + \upsilon_{i,t} \quad (9)$$

where $Q(Pol_stab_{i,t})$ are the different quantiles of the index of political stability in country i and time t; $out_degree_{i,t}$ and $in_degree_{i,t}$ are, respectively, our measures of out-degree and in-degree in country i and time $t-1$; $X^{OD}_{i,t-1}$ is the set of covariates accounting for oil dependence in country i and time $t-1$; $X^{SE}_{i,t-1}$ is the set of socioeconomic factors influencing political stability in country i and time $t-1$; $X^{PI}_{i,t-1}$ is the set of political-institutional characteristics that can structurally affect institutional quality and development in country i and time $t-1$. Finally, β_0 and γ_0 are the intercepts and $\varepsilon_{i,t}$ and $\upsilon_{i,t}$ are the error terms.

Unlike parametric regression models, to obtain the standard errors and confidence intervals of estimated coefficients with the simultaneous-quantile regression, the default method that uses the fitted values for the predicted quantiles does not perform well in large samples. For this reason, the standard method for estimating the variance-covariance matrix of the estimators with simultaneous-quantile regression is to provide a bootstrapped estimate. This method was first introduced by Efron (1979) and allows to draw samples of size n with replacement from the observed data. In this study we perform a total of 200 replications.

4. Main results

The baseline regressions include two models tested simultaneously on the 25th, 50th and 75th quantiles of the dependent variable, to analyse the effects of out-degree (Table 3) and in-degree centrality (Table 5) on political stability. In addition to our key independent variables, basic controls include average oil price, an index of democracy and GDP per capita. In general, both our research hypotheses are empirically validated.

In the case of out-degree (Table 3), the coefficient is negative and significant for all quantiles of the distribution of our dependent variable, indicating that a position of greater centrality in the crude oil export network systematically affects political stability, irrespective of the positioning within the conditional distribution of Y. Nonetheless, the magnitude of the coefficients tends to decrease as we move to higher quantiles. As for basic controls, we find that an increase of average oil price negatively affects political stability in all quantiles. As suggested by Chen and Hsu (2012), in countries depending on oil exports as their main income source, an increase in oil prices discourages international trade, diminishing oil revenues and economic growth. This can, in its turn, induce internal turmoil and political instability. This finding is also in line with those for GDP per capita, whose coefficient is positive and significant in all quantiles, indicating that income growth enhances stability. Finally, democratic regimes are also conducive of political stability and this result is true for all quantiles analysed.

The advantage of simultaneous-quantile regression over quantile regression, which estimates a single quantile at a time, is that here the full variance-covariance matrix is estimated and stored and, hence, it is possible to perform hypothesis tests. Hence, we ask whether the effects of out-degree in Table 3 are the same for the 25th and the 75th quantile. In this case, the answer is yes, since Prob > F = 0.654. This would mean that, in this case, using quantile regression in place of standard OLS regression does not add much to our estimation. However, results are different when we include additional controls, as in Table 4. In this case, Prob > F = 0.005, indicating that the estimated effect of out-degree centrality at the 25th quantile is not the same as at the 75th.

Table 3 – Baseline model for out-degree centrality

	Q25	**Q50**	**Q75**
oil_price_t1	-0.004***	-0.005***	-0.005***
	(0.00)	(0.00)	(0.00)
democ_t1	0.021***	0.020***	0.013***
	(0.00)	(0.00)	(0.00)
GDP_pc_t1	0.000***	0.000***	0.000***
	(0.00)	(0.00)	(0.00)
out_deg_n_t1	-5.972***	-5.432***	-5.317***
	(1.65)	(0.62)	(0.58)
constant	-0.781***	-0.135***	0.375***
	(0.04)	(0.03)	(0.03)
N	3,693	3,693	3,693

Note: standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01

In Table 4, we present results for two different models in which we introduce additional controls. In Model 1, we include two measures of inequality, namely the Gini index and the degree of ethnic discrimination, and countries' legal origins. Even in this case, results for control variables are robust across all three quantiles. As for our main variables of interest, we have that out-degree centrality is still negative and significant, but the magnitude of the coefficients reduces more sharply in Q50 and Q75 compared to Q25, as already evident from the hypothesis test. The two inequality measures have a negative effect on political stability in both Model 1 and 2 and in all quantiles, but the Gini index is not significant for countries in the 25th quantile, where other factors may be more relevant for explaining variations in our dependent variable. Looking at countries' legal origins, we can notice that British and French institutional legacies are relatively more detrimental to political stability, compared to other legal origins. The only exception is Q75 in Model 2, where British legal origins are not significant. In Model 2, we further extend Model 1 by including a measure of economic dependence on oil extraction, represented by the share of GDP captured by oil rents. However, it has no effect on any quantile of political stability.

Table 4 – Extended models for out-degree centrality

	Q25		Q50		Q75	
	Model 1	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**
out_deg_n_t1	-5.400***	-5.412***	-2.772***	-2.983***	-3.138***	-3.830***
	(1.12)	(1.03)	(0.95)	(0.96)	(0.73)	(0.95)
oil_price_t1	-0.004***	-0.004***	-0.005***	-0.005***	-0.005***	-0.005***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
democ_t1	0.019***	0.018***	0.014***	0.015***	0.013***	0.013***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GDP_pc_t1	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
gini_t1	-0.336	-0.157	-0.790***	-0.725***	-1.084***	-1.100***
	(0.33)	(0.29)	(0.21)	(0.22)	(0.15)	(0.22)
discr_t1	-2.050***	-2.131***	-2.004***	-2.046***	-1.379***	-1.311***
	(0.33)	(0.45)	(0.2)	(0.23)	(0.23)	(0.18)
legor_uk_t1	-0.311***	-0.325***	-0.216***	-0.223***	-0.080**	-0.073
	(0.06)	(0.07)	(0.04)	(0.05)	(0.04)	(0.05)
legor_fr_t1	-0.439***	-0.441***	-0.357***	-0.359***	-0.214***	-0.216***
	(0.05)	(0.06)	(0.04)	(0.04)	(0.03)	(0.05)
legor_ot_t1	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
oil_rents_t1		-0.003		0.001		0.002
		(0.00)		(0.00)		(0.00)
constant	-0.174	-0.262	0.650***	0.612***	1.139***	1.150***
	(0.19)	(0.16)	(0.13)	(0.12)	(0.08)	(0.11)
N	3,680	3,649	3,680	3,649	3,680	3,649

Note: standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Turning to in-degree centrality within the crude oil trade network, in Table 4 we employ as controls the same variables as in Table 4. Even in this case, all control variables retain their signs and significance. Conversely, results for our key independent variable, in-degree centrality, are very different across quantiles. While no effect is found for countries in the 25th and 50th quantiles, countries in the 75th quantile, which are structurally more stable, are negatively affected if they occupy a position of greater in-degree centrality, indicating the plausibility of our hypothesis of imported instability. This is in line with what we expected, as countries in the 75th quantile of political stability are all net-importers of crude oil. This is also confirmed in the hypothesis test: contrary to the hypothesis tests for out-degree centrality, in the case of in-degree centrality the difference between the 25th and the 75th quantile is stark in both the baseline (Table 4) and the complete models (Table 6), as in both cases Prob > F = 0.000. This means that running standard OLS regression would lead to biased results, which can be corrected by means of quantile regression.

Table 5 – Baseline model for in-degree centrality

	Q25	Q50	Q75
oil_price_t1	-0.004***	-0.005***	-0.006***
	(0.00)	(0.00)	(0.00)
democ_t1	0.021***	0.021***	0.013***
	(0.00)	(0.00)	(0.00)
GDP_pc_t1	0.000***	0.000***	0.000***
	(0.00)	(0.00)	(0.00)
in_deg_n_t1	0.272	-0.587	-2.621***
	(0.87)	(0.61)	(0.85)
constant	-0.821***	-0.148***	0.386***
	(0.05)	(0.03)	(0.04)
N	3,693	3,693	3,693

Note: standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01

Analogously to Table 4, we extend baseline regressions by including additional controls in Table 6. In this case, we estimate three different models, in which we progressively add controls. Control variables of Model 1 in Table 4 and 6 are the same and all coefficients retain the same sign and significance. The coefficient of in-degree centrality in the 50th percentile becomes here significant, contrary to the baseline regression in Table 5. In model 2, we also control for countries' energy mix, assuming that countries in which the share of oil on total primary energy (captured by the variable *oil_share*) are more exposed to geopolitical forces, increasing internal political instability. Results in Model 2 confirm our hypothesis, given the negative and significant sign in all quantiles. Finally, in Model 3 we include a measure of energy dependence on oil (*energy_dep*), measured by the interaction between in-degree centrality and the share of oil on total primary energy. While for countries in Q50 energy dependence is not a driver of political stability, results are opposite for countries in Q25, where a higher energy dependence enhances stability, and in Q75, where a higher energy dependence on oil induces political instability. In the former quantile this result can be explained by the fact that most of the countries included are oil producers and/or exporters (e.g., Venezuela, Algeria and other Gulf and emerging economies), so their share of imported oil is neglectable. Results for countries in Q75 can be intuitively explained considering that they are almost all net-oil importers and that a greater in-degree centrality in these countries induces instability *per se*. Accordingly, the higher their share of imported oil, the higher their risk of instability.

Table 6 – Extended models for in-degree centrality

	Q25			Q50			Q75		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model_3
in_deg_n_t1	0.424	0.944	-0.419	-1.877***	-1.516***	-1.321	-2.595***	-2.615***	-1.327**
	(0.55)	(0.73)	(0.6)	(0.45)	(0.46)	(1.13)	(0.51)	(0.47)	(0.55)

oil_price_t1	-0.004***	-0.005***	-0.006***	-0.005***	-0.006***	-0.006***	-0.005***	-0.007***	-0.006***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
democ_t1	0.018***	0.022**	0.022***	0.015***	0.014***	0.014***	0.013***	0.011***	0.010***
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GDP_pc_t1	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
gini_t1	-0.642	-2.952***	-3.010***	-0.921***	-1.955***	-1.943***	-1.102***	-1.694***	-1.689***
	(0.48)	(0.58)	(0.38)	(0.27)	(0.22)	(0.26)	(0.23)	(0.22)	(0.25)
discr_t1	-2.012***	-2.806***	-2.924***	-2.083***	-3.174***	-3.170***	-1.627***	-3.435***	-3.432***
	(0.43)	(0.34)	(0.32)	(0.15)	(0.49)	(0.52)	(0.28)	(0.42)	(0.44)
legor_uk_t1	-0.280***	-0.357***	-0.323***	-0.239***	-0.174***	-0.172***	-0.122***	-0.068	-0.076**
	(0.07)	(0.11)	(0.08)	(0.04)	(0.05)	(0.05)	(0.04)	(0.05)	(0.04)
legor_fr_t1	-0.409***	-0.451***	-0.443***	-0.366***	-0.419***	-0.419***	-0.210***	-0.351***	-0.357***
	(0.07)	(0.05)	(0.05)	(0.03)	(0.04)	(0.03)	(0.06)	(0.03)	(0.04)
legor_ot_t1	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
oil_share_t1		-0.006***	-0.007***		-0.002*	-0.002		-0.001*	-0.001
		(0.00)	(0.00)		(0.00)	(0.00)		(0.00)	(0.00)
energy_dep_t1			0.000**			-0.00			-0.000**
			(0.00)			(0.00)			(0.00)
Constant	-0.038	1.654***	1.732***	0.729***	1.474***	1.460***	1.156***	1.621***	1.596***
	(0.27)	(0.35)	(0.21)	(0.15)	(0.12)	(0.17)	(0.11)	(0.13)	(0.15)
N	3,680	1,820	1,820	3,680	1,820	1,820	3,680	1,820	1,820

Note: standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusions

The economic recovery from the recession induced by the Covid-19 has slowed down the advances made in the energy transition, with a large rebound in coal and energy use in 2021 and, consequently, a large increase in CO_2 emissions (IEA, 2021). This makes the way to net-zero emissions longer, and re-opens a series of questions related to energy security and oil dependence.

In particular, by employing network analysis and simultaneous-quantile regression, our work sheds new light on the relationship between crude oil and political stability. The analysis of the crude oil international network reveals information on the dynamics of out-degree and in-degree centrality, which resume countries' centrality within the crude oil trade network in relation to the export and the import side, respectively. We then exploit this information to estimate the impacts that oil dependence can have on countries' internal political stability. Oil dependence can be declined in two different ways for exporting and importing countries: for the former, crude oil can represent the main source of revenue (economic dependence); for the latter, it can absorb the greatest share of a country's energy

mix, exposing importing countries to the instability of oil producer countries (energy dependence). Our findings confirm our two research hypotheses: first, they corroborate the resource curse hypothesis in relation to oil-exporting countries, especially confirming the theory of Mehlum et al. (2006b) of a double resource curse, induced by the deteriorating effect of natural resources on the quality of institutions. Second, we find that energy-dependent countries import political instability together with oil: shifting their energy dependence from oil to renewable resources becomes even more important, as it involves issues related to sustainable transition, energy security and internal stability.

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