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Quantifying the geopolitical dimension of energy risks: A tool for energy modelling and planning

Beatriz Muñoz [a,*], Javier García-Verdugo [b,1], Enrique San-Martín [b,2]

[a] Department of Economic Analysis: Economic Theory and Economic History, c/Francisco Tomás y Valiente 5, Universidad Autónoma de Madrid, 28049 Madrid, Spain

[b] Department of Applied Economics, c/Senda del Rey 11, Universidad Nacional de Educación a Distancia (UNED), 28040 Madrid, Spain

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ABSTRACT

Energy risk and security are topical issues in energy analysis and policy. However, the quantitative analysis of energy risk presents significant methodological difficulties, especially when dealing with certain of its more qualitative dimensions. The aim of this paper is to quantitatively estimate the geopolitical risk of energy supply with the help of a multivariate statistical technique, factor analysis. Four partial energy risk factors were computed for 122 countries, which were subsequently aggregated to form the composite GESRI (Geopolitical Energy Supply Risk Index). The results demonstrate that advanced economies present a lower level of geopolitical energy risk, especially countries with energy resources, while less-developed countries register higher levels of risk regardless of their energy production. Although this indicator is computed for countries, it can be aggregated for regions or corridors, and it could also be applied to model and scenario building. The different uses of the GESRI could eventually lead to practical implications in the energy policy field, as well as in the energy planning and energy management areas.

1. Introduction

Energy security is a multidimensional concept comprising technical, economic, social, political, environmental and geopolitical aspects that are mutually interdependent. Energy security refers here to consuming countries, so that it is equivalent to “security of energy supply” throughout this paper.

According to most official definitions of “security of energy supply” (e.g., Refs. [1–3]), a failure in energy security occurs whenever there is an interruption in the physical flow of energy toward a consuming country or a substantial rise in energy prices. However, because price variations are a consequence of actual or expected changes in energy supply or demand, the price component of energy security can be considered an endogenous variable and kept out of our analysis, notwithstanding the undeniable importance of price fluctuations on economic growth and social welfare.

Therefore, a country's energy security is dependent on two components inextricably connected:

a) A system of energy supply corridors[3] and a set of related indicators that indicate the country's need for energy resources, its dependence on energy imports, the geographical concentration of its suppliers, and its interconnection with producing and transit countries [5–12].
b) The geopolitical situation of the producing and transit countries that form the energy supply corridors, which is much more difficult to define and measure [4,13–15].

In a previous publication [16], we considered in some detail a wide array of simple and composite indicators related to energy security. According to that survey, it seems clear that the use of

* Corresponding author. Tel.: +34 914973020.
E-mail addresses: beatriz.munoz@uam.es (B. Muñoz), fgarcia-verdugo@cee.uned.es (J. García-Verdugo), esanmartin@cee.uned.es (E. San-Martín).
[1] Tel.: +34 913987389.
[2] Tel.: +34 913987841.

[3] An energy corridor comprises all countries involved in the extraction, processing, handling and transport from the point of origin of an energy source to the importing country's border [4].

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quantitative indicators—similar to those used to measure a country's energy dependence or vulnerability—is not the best way to analyse the geopolitical context of energy corridors. It is customary to seek the opinion of experts to form a subjective idea of the possible repercussions of the geopolitical situation on a country's energy security. The paper by Sovacool and Mukherjee [17] can be cited as a recent example of this approach, although it received some criticism from Cherp [18]. These analyses are habitually coined in qualitative form and cannot therefore be included in a rigorous manner in quantitative models or assessments. On the other hand, when a quantitative approach is favoured, the researchers usually give up the aggregation of variables [19] due to problems such as standardisation and weighting, or they tend to use methods that may be over-simplistic [20]. IIASA's *Global Energy Assessment* [21] presents an innovative solution consisting in aggregating not energy risks but the population that bears them. Although this approach may help establish global policy priorities, it is not useful when trying to perform international comparisons or to study the evolution of risks over time.

To make matters more complicated, the geopolitical situation is hardly stationary. Future values of economic variables can be estimated with a certain degree of probability; by contrast, the most experienced analysts are not able to foresee how the geopolitical situation will evolve in the near future, so that forecasts about the international political scene can be no more than educated conjectures. For this reason, the analyses of the international geopolitical context in the future traditionally resort to the use of scenarios. Scenarios are not forecasts but alternative narratives about what could happen in the future based on some critical parameters of the international energy system. They are useful as a tool for decision making in the presence of uncertainty but cannot avoid the use of subjective criteria to characterise the different scenarios.

Considering all the above, the analysis of energy security would greatly benefit if a way could be found to assess the geopolitical context with a single quantitative indicator. With that in mind, in a previous publication [22], we presented a preliminary method to quantitatively estimate energy supply risks due to geopolitical factors and applied it to obtain some tentative results. However, the original database only included data through 2005, so that the analysis performed in that paper could not take into account the effects of the economic crisis that began in 2007, nor certain relevant changes that have taken place since then in countries that are crucial for the global energy industry, such as those mentioned in the previous paragraph. In addition, the method used in that paper had some practical limitations and technical difficulties that were noted by some colleagues and anonymous referees. This paper aims, therefore, not only to update the data but to complete and refine the original method to make it more robust with the hope that the new version may be more useful and reliable for researchers and energy actors, such as policy-makers and business managers, as a more rigorous tool to address objectively energy risk and contribute to energy planning and management.

2. Methods

2.1. Identifying and quantifying the dimensions of geopolitical energy risk

From the main categories of energy risks identified in the literature [2,15,17,23–28], a causal typology of energy risks is selected in this section that will be later used to estimate the energy risks due to geopolitical factors, to which we will refer more briefly as geopolitical energy risks.

Primary or causal energy risks comprise geopolitical and technical risks.[4] The primary energy risks of both groups that originate inside the importing country should be managed with relative ease by the national authorities. Therefore, geopolitical energy risks are assumed throughout this paper to be generated abroad by the exporting and transit countries that form the energy corridors toward the importing country. Similarly, technical energy risks refer to threats to the physical infrastructures of those same corridors, but they are beyond the scope of this paper and will not be considered in the analysis that follows despite their importance.[5]

Geopolitical energy risks can be generally grouped into three categories corresponding to the economic, political and social aspects of human activity; in addition, because energy is the focus of this paper, it would seem advisable to add a fourth category of variables specifically related to the energy sector. Therefore, the four energy risk vectors associated with the social, political, economic and energy-related variables would determine the geopolitical reliability of the exporting and transit countries that form the energy corridors toward a country. These four risk vectors can be said to be objective indicators in the sense that they are based on the country-level data compiled and released by reputed institutions or scholars. Our previous work [22] used these four dimensions of the geopolitical energy risk.

However, because our attention was limited to these four groups of variables, we were overlooking the possible effect of the interrelation between the energy-importing country and all the countries that take part in its supply. Close commercial, diplomatic and cultural ties between the importing, exporting and transit countries can be expected to reduce the geopolitical risk of energy supply for the importing country. Therefore, it would be necessary to include the additional dimension of bilateral relations to our analysis [30]. Because the European Union (EU) as an energy importer is the reference point for our risk analysis, an EU-relations dimension was added to capture how a country's level of geopolitical energy risk depends on the nature and intensity of its bilateral relations with the EU-27.[6] Moreover, the variable “Relations with Neighbouring Countries” [33] was also included in the socio-political dimension to extend this rationale to neighbouring countries belonging to the same energy corridor.

Most geopolitical risk factors cannot be estimated as probabilities because objective probabilities cannot be obtained from existing data. This crucial issue makes it quite difficult to build quantitative scenarios about the geopolitical context or to combine the geopolitical data with quantitative scenarios. For instance, if the political stability of an exporting country is assessed in terms of the number of terrorist attacks during a certain period, the probability of new attacks could be estimated in theory. However, it is more difficult to quantify the influence on an importing country's energy risk of the institutional quality, the level of corruption or the political alignment of an exporting or transit country; but all of these are relevant variables that might contribute to determine the situation that will be faced by energy-importing countries in the future.

[4] Some examples of threats to security of supply and the causes of these threats can be found in Ref. [29].

[5] Researchers from the Politecnico di Torino (Italy) produced very interesting results during the REACCESS Project in the definition and estimation of the technical and environmental risks that affected the security of energy corridors toward the European Union (see http://reaccess.epu.ntua.gr/).

[6] When the empirical part of this paper was already completed using data for the EU-27, Croatia became the 28th member of the EU. A brief analysis of the European energy policy can be found in Ref. [31], while [32] study in depth the external dimension of the European energy policy.

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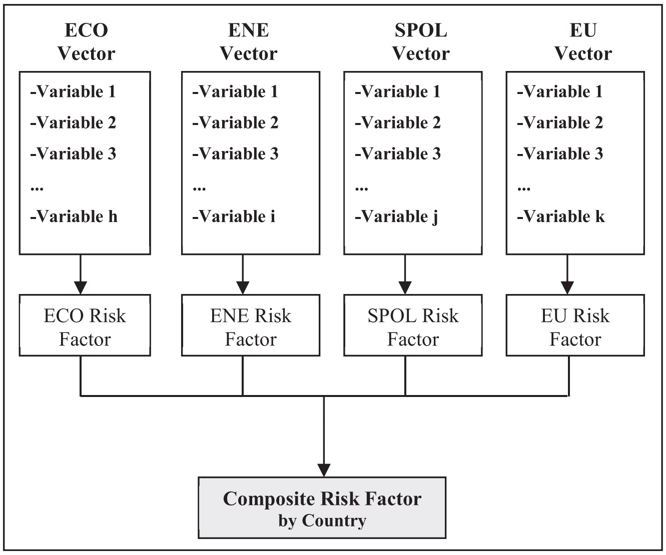

Fig. 1. Quantifying the geopolitical energy risk of a country.

The quantification of geopolitical energy risk and its components thus entails several difficulties:

a) No single variable allows us to observe directly the geopolitical situation of an exporting or transit country; therefore, adequate proxies have to be chosen.
b) The variables used as proxies for the geopolitical factors (e.g., the level of government corruption) are not directly related to the potential interruption of energy supply. Instead, a series of related political, social and economic variables frequently jointly provide information about the relative situation of a country regarding the risk factor that is being quantified.

Taking all these restrictions into account, it would seem that the most rigorous approach to quantify geopolitical energy risk is to use simultaneously all the relevant variables related to the five geopolitical risk vectors considered to obtain a composite measure for each country and risk vector. However, our previous work with geopolitical energy risk indicators [22,30] indicates that an almost perfect positive correlation exists between the political and social vectors (a Pearson coefficient of 0.93). As a result, it seemed preferable to combine all social and political variables in one risk vector.[7]

Therefore, the four dimensions of the geopolitical energy risk that will be used in this paper will be referred to in abbreviated form as the ECO (economic risk vector), the ENE (energy-specific risk vector), the SPOL (socio-political risk vector) and the EU-relations risk vector (EU), as can be observed in Fig. 1.

An additional selection criterion for the estimation method of the geopolitical energy risk is that it should preferably yield cardinal values for the indicators of each risk vector, i.e., it should provide meaningful information about the relative level of geopolitical energy risk in different countries and not just a ranking of countries.

Fortunately, a statistical technique is in fact available that adequately fulfils all the requirements described above, factor analysis. This technique was chosen as the best option for this paper, as will be observed in more detail in subsection 2.2.

Once the estimation method is chosen, the risk factors of the four dimensions of the geopolitical energy risk can be estimated. However, a decision has yet to be made about the most suitable way to aggregate the indicators of the four components to obtain a global estimate of the geopolitical energy risk (see Fig. 1). The problem is that there is no clear-cut solution to allocate the weights to the different components of a composite indicator. In our previous work [22], a simple average of the partial indicators was used, i.e., each one was given the same weight, which is most likely the best alternative without additional information.

In this context, an interesting study by Komendantova et al. [34] ranks the risks of investing in renewable energy projects in North Africa according to the assessment of experts. Although their paper is focused on a specific region and industry, the threats considered by them—regulatory and political risks, force majeure problems, technical, financial, operational, income-related and environmental risks—are also relevant to our analysis. Interestingly, they conclude that the three highest categories of risk are those related to political variables, while the rest were considered of average or low importance [34]. Consequently, it seemed advisable to assign to the socio-political risk vector twice the weight of the other three components of geopolitical energy risk, which also makes sense because the socio-political dimension of energy risk comprises two groups of variables. In short, the economic, energy-specific and EU-relations components of the geopolitical energy risk will have a 20 per cent weight, while the socio-political dimension will have a 40 per cent weight.

2.2. Quantifying the energy risk of the geopolitical context: the GESRI (Geopolitical Energy Supply Risk Index)

Factor analysis is a multivariate statistical technique that can be applied—among other possible uses—to reveal and measure phenomena that are not directly observable. Factor analysis assumes that the information shared by a group of variables can be revealed in the common correlation between these variables and that the source of this correlation is the presence of an underlying common factor that reveals a dimension that was not directly observable. This technique can therefore be used to quantify or estimate the value of common unobservable factors from observable variables.

An added advantage of this technique is that it does not require the researcher to decide a priori the variables that will be included in the composite indicator, but provides a method to validate the relevance of the variables for the common factor using their mutual correlation. A more detailed explanation about this technique and the calculation process can be found in Appendix A.[8]

It was previously said that a country's geopolitical energy risk (to the EU) can be described as the combined result of four risk components that correspond to the economic, energy-specific, socio-political and EU-relations dimensions. Although no single variable can be used to estimate these risk components, a group or vector of highly correlated variables can be identified for each component that could be used in factor analysis to reveal the four underlying dimensions of the geopolitical energy risk or partial risk factors.

Our database is organised by country. The main sources of information are the statistics released by international organisations, research institutes and reputed individual scholars. Data sources for each variable are shown in Appendix B.

[7] There is also a significant—but much lower—correlation between the economic vector and the other risk vectors (0.49 with the energy vector, 0.32 with the social vector and 0.23 with the political vector). The other correlations are not significant.

[8] For further information see Ref. [35] and a more recent approach in Ref. [36].

As a starting point and based on the literature review mentioned above, a set of critical variables was selected from the database, i.e., those that were considered indispensable to represent correctly each of the geopolitical energy risk dimensions. The essential variables for each risk vector were selected according to their theoretical relevance and the quality of the available data.[9] As a result, 143 variables were initially selected from the database for 122 countries (the sample included all countries with reliable data for the initial selection of variables): 34 variables for the economic risk vector, 51 for the energy-specific risk vector, 43 for the socio-political risk vector, and 15 for the EU-relations risk vector. The 143 variables used in the factor analyses are listed in Appendix B with their units, number of countries with available data, periods of time and sources.

To avoid the influence of outliers, the data of the selected variables were aggregated over the period 2000–2010 before using them as inputs for the factor analyses. This time interval was considered sufficiently wide that the aggregated data might adequately represent the risk level of each country.

An indirect consequence of this temporal aggregation is that the availability of more recent data should not radically change the estimated energy risk factors, i.e., the values estimated for the components of geopolitical energy risk. Therefore, it would not be necessary to update the database and run new factor analyses every time new information is released.

Nonetheless, some changes in a country's political or social variables may have a decisive impact on its geopolitical energy risk. For instance, the popular revolts and reformist movements that have flourished in North Africa and the Middle East since the end of 2010 have changed a significant number of variables that were used in the factor analyses performed for this paper, so it is quite possible that the values of the partial risk factors and the composite indicator presented here may have changed with them. Considering the significant lag in the publication of international data, especially in developing countries, it would have been difficult to include these new developments at the time that our econometric analysis was being performed. In any case, this caveat should be taken into account when examining the results presented in Table 3 regarding Algeria or the values for Tunisia, Syria, Egypt and Libya.

The principal components extraction method was selected as the most robust and unbiased. Iterative factor analyses were performed using the set of variables initially selected for each geopolitical energy risk vector. They were performed separately on each risk vector without imposing restrictions on the relations between the variables. The criteria to select and discard variables were the sample adequacy test, the degree of correlation between the variables, and the sign of the correlation coefficient.[10] The relative importance of each variable was automatically determined by the factor analysis algorithm according to its variance. The variables finally included in each geopolitical risk vector by the factor analysis algorithm are presented in Appendix C, Tables C.1–C.4.

Finally, Z-scores (the normalised factor scores) were computed for each risk component and country using a regression. The factor scores were then aggregated to produce a composite indicator of geopolitical energy risk by country, the GESRI (Geopolitical Energy Supply Risk Index). An interpretation of the results for a selection of countries is performed in section three, while the complete results for all countries are presented in Appendix C, Table C.5.

2.3. *Variables finally selected by the factor analysis algorithm for each factor of geopolitical energy risk*

The four vectors of variables that were finally selected for each dimension of geopolitical energy risk are presented next, as well as the different categories or components within each vector. These vectors, categories and number of variables included in the geopolitical energy risk vectors are summarised in Table 1, while the variables in each group are listed in Appendix C, Tables C.1–C.4. A brief explanation about the relation between these categories and the geopolitical energy risk is included.

It should be underscored that the grouping of variables by categories in each vector is determined by the factor analysis algorithm according to the correlation between variables. As a result, related variables may appear in different categories rather than in one homogenous category, contrary to what might be expected.

The first vector includes the economic variables that are relevant for the economic component of the geopolitical energy risk, i.e., the economic factors that may affect energy supply. Table 1 displays the three categories into which this group of variables is divided and the number of variables eventually selected for each category.

ECO1 comprises several variables related to the stability, competitiveness and openness of an economy. Market disturbances, macroeconomic instability and lack of competitiveness are part of an economic risk that may negatively affect the performance of energy markets and the availability of potential investments in the energy sector, which could in turn damage the energy supply security both in the short and in the long run. On the other hand, developed and stable economies are more capable of providing for the material needs of their citizens and of fostering a stable and peaceful environment. This will help reduce social conflicts and country risk.

An additional important element of the economic risk vector is energy demand. Variables related to the level of energy demand are positively correlated with geopolitical energy risk because a country with high domestic demand is usually associated with high energy intensity and implies increased competition for energy resources in the international markets, leaving fewer resources available for the remaining consuming countries. ECO2 comprises

Table 1
Categories and number of variables included in the geopolitical energy risk vectors.

Vector	Categories	Number of variables
Economic	ECO1: Freedom and economic stability	6
	ECO2: Size of the economy and energy consumption	4
	ECO3: Fiscal policy on energy	2
Energy-specific	ENE1: Production and exporting capacity of oil and gas	3
	ENE2: Duration of oil and gas reserves	2
	ENE3: Net trade in oil and gas in relative terms	2
Socio-political	SPOL1: Socio-political stability and institutional quality	8
	SPOL2: Political and social violence	5
	SPOL3: Market power	2
	SPOL4: Social diversity and inequality	2
EU-relations	EU1: Level of political association with the EU	5
	EU2: FDI flows with the EU and the EU's energy imports	3
	EU3: Trade relations and treaties with the EU	3

[9] Data quality refers to the independence and reliability of the sources, the availability of systematic and homogeneous data for most countries, the access to up-to-date data and the metric nature of their scale.

[10] The expected correlation sign between each variable and the underlying common factor was set a priori from a theoretical perspective. The final selection of variables for each risk vector was determined according to whether the actual correlation sign was as expected—was "correct", so to speak—or not.

different variables related to the size of the economy and domestic energy consumption.

The third category within the vector of economic risk (ECO3) is also related to domestic energy demand but now from the perspective of taxes and subsidies on energy consumption, especially of diesel and gasoline. It is common to find subsidies for energy consumption in oil—and gas—exporting countries, and the higher demand that follows results in lower international energy availability and higher prices. Conversely, importing countries usually establish taxes on energy consumption, with a negative correlation between both variables.

The second group of variables in our database include those that try to capture the energy-specific component of geopolitical energy risk. Table 1 displays the three categories within the energy-specific vector of energy risk. ENE1 reflects the availability of hydrocarbons in the short and long run in exporting and transit countries using the proven reserves, hydrocarbon production rates and export share as variables. Countries with high reserves and high production capacity will draw fewer resources from—or will contribute with more exports to—the international energy markets and will therefore pose a lower risk of energy shortages for other countries.

The second category within the energy-specific vector of risk (ENE2) is related to the availability of supply in the long run. The variables included in ENE2 refer to the duration of reserves of natural gas and crude oil. The third category (ENE3) indicates the hydrocarbon dependence relative to hydrocarbon needs and to the size of the economy. The two variables included are the net trade in oil and gas in relation to hydrocarbon consumption and to GDP, which can be interpreted in a similar vein for the variables included in ENE1.

The third vector of our database comprises the socio-political variables. Table 1 displays the four categories within the socio-political vector of energy risk.

It is reasonable to assume that conflicts within a country could negatively affect the stability of its energy system and could give rise to supply interruptions. The first category (SPOL1) of this vector is formed of variables that capture the socio-political stability and the institutional quality of countries, both essential factors for the stability of the energy industry. In addition, it includes an indicator of the countries' relations with their neighbours. The next category, SPOL2, refers to the different instances of violence and instability in a country—such as terrorist attacks, number of displaced people and coups d'état—that pose a severe threat to the investment climate and to infrastructures and therefore to energy security.

The use of energy as a political weapon is typical of agents with market power such as the exporting countries, energy cartels and large energy companies. Energy supply is then influenced by political interests so that the possibility of supply disruptions increases independently of the evolution of market fundamentals. This important aspect of the socio-political vector of energy risk has been included in the third category (SPOL3).

The last category (SPOL4) attempts to capture the social inequality and fractionalisation that could result in future conflicts such as riots and revolts, with negative effects on energy infrastructures and energy activity.

The last vector of our database is formed by the variables with information about the EU's bilateral relations with energy suppliers and transit countries. Table 1 presents the three categories of variables that form the EU-relations component of energy risk.

The level of political association with the EU is a useful sign of the importance of third countries for the EU, as well as a measure of the degree of mutual commitment and trust.

This category (EU1) comprises 1) the level of integration in the EU institutions; 2) the affinity between countries in terms of their votes in the UN General Assembly; 3) the level of commitment to the Energy Charter; 4) the percentage of total exports to the EU; and 5) the number of bilateral and multilateral treaties with the EU. Other things constant, the higher the level of association is, the more stable and reliable the relations with the EU will be, resulting in a higher security of energy supply for the EU: A close relationship increases the cost of an energy dispute and makes a conflict less probable.

EU2 comprises two variables related to foreign direct investment (FDI) flows and a third variable that measures the EU's hydrocarbon imports, which presents a high correlation (0.60) with the other two variables. This means that there is a significant relation between FDI and the exchange of energy flows with the EU. When these flows are larger, the climate for economic and political relations can be expected to be more favourable due to the interdependence between other countries and the EU, and the possibility of an interruption of the EU's energy supply is reduced.

Finally, the third category (EU3) captures the intensity of trade relations and the commercial and energy agreements with the EU.[11] A high commercial complementarity and a significant number of treaties would suggest more intense mutual relations, which would tend to preclude conflicts between those countries and the EU.

3. Results

Data adequacy tests and quality indicators assessing the results of the four factor analyses are presented in Table 2. The final number of variables selected for each energy risk factor is displayed in the second column.

The Kaiser-Meyer-Olkin (KMO) and the Bartlett tests (columns 3 and 4) are two of the most common techniques used to test sample adequacy by measuring the strength of the relations between variables.[12] The final selection of the variables for each risk vector seems to be technically correct because all KMO test values are quite high (between 0.74 and 0.86), and the Bartlett test indicates that the relations between variables are significant in all four dimensions.

The average single communality for the four dimensions was between 0.73 and 0.89 (column 5). The interpretation of these values is quite straightforward. For instance, the average single communality of the economic risk dimension is 0.77, which means that the three categories of variables included in that risk dimension jointly explain over 77% of the total variance in the economic risk vector (see the remaining in column 6). The four values of average single communality are quite high, which confirms that the data variation was adequately explained in all four risk dimensions. Moreover, in 94% of the cases, the communality between the variables included in the factor analyses was higher than 0.6. Therefore, it can be concluded that the variables finally considered in each risk vector have a simple communality that is reasonably high.

The residuals indicate the difference between the observed correlation for two variables and the correlation that is replicated by the factor structure for those same variables. A low proportion of residuals with absolute values larger than 0.05 would confirm a suitable goodness-of-fit for the selected model. The residuals of

[11] It should be remembered that the grouping of variables in each category is determined by the factor analysis algorithm. Therefore, related variables such as total energy exports, energy imports and trade in energy products appear in different categories rather than in the same one, contrary to what might be expected.

[12] The KMO consists of an index (between 0 and 1, with 1 indicating the highest sample adequacy) that indicates the intensity of the relation between variables and whether the variables share a latent common factor or not. The Bartlett sphericity test checks for significant correlations.

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Table 2
Summary of quality indicators of the factor analyses.

Risk factor	Final number of variables	KMO test[a]	Bartlett test	Average simple communality	Total explained variance	Residuals with absolute values larger than 0,05
Economic	12	0.74	0.00	0.77	77.48	25%
Energy-specific	7	0.75	0.00	0.89	88.56	14%
Socio-political	17	0.82	0.00	0.73	73.14	30%
EU-relations	11	0.86	0.00	0.82	82.15	30%

[a] Kaiser-Meyer-Olkin Test.

the four risk factors range between 14% for the energy-specific factor and 30% for the socio-political and EU-relations factors (see column 7).

The final result of our factor analyses is one country estimate for each of the four components of geopolitical energy risk. Afterwards, the four partial-risk factors for each country have to be converted into indices with a 0–100 scale for inter-factor comparability. It should be stressed that the values of the partial country-risk factors depend on the net effect of a large number of variables with different signs and weights, so that their interpretation is not always intuitive.

It was noted at the end of the subsection 2.1 that a reasonable method to combine the partial country-risk estimates into a composite indicator of geopolitical energy risk for each country would be to use a weighted average. More specifically, it was decided that the socio-political risk estimate should receive a 40 per cent weight, while the other three partial-risk estimates would be equally weighted with 20 per cent. The result is a composite index with the same 0–100 scale that we have called the GESRI (Geopolitical Energy Supply Risk Index).

Table 3 summarises, for a representative selection of countries, the indices computed for the GESRI and its four dimensions. The countries are ranked from lower to higher in terms of the geopolitical energy risk, with the less risky countries at the top. To help identify the different values, the cells in Table 3 have been shaded. A dark grey shade represents the values above the third quartile (25% of the higher values); a light grey shade indicates the values between the first and the third quartile (50% of the intermediate values); and the cells without shade contain the values below the first quartile (25% of the lower values).

It should be stressed again that the numerical results produced by factor analysis are not ordinal but cardinal numbers that can be used to assess quantitatively the relative geopolitical energy risk of any two countries.

The computed values for the same partial and global indices can be found in Appendix C, Table C.2, for all the countries included in our analysis (the cells are shaded as in Table 3). Map 1 depicts the GESRI values for the 122 countries included in our study. The EU-27 member countries and the 40 countries that are part of the hydrocarbon corridors toward the EU are highlighted with dots and lines, respectively.

In terms of the socio-political dimension of energy risk, the more advanced economies achieve higher levels of individual freedom, democracy, political and social stability, etc., which are

Table 3
GESRI and components for selected countries.1

Ranking[b]	Country	GESRI[a]	Components			
			ECO	ENE	SPOL	EU
1	Norway	**30.15**	13.23	57.27	16.67	46.94
13	Switzerland	**34.55**	11.64	81.35	17.77	44.20
14	Canada	**34.88**	23.84	62.48	19.36	49.37
17	Iceland	**35.61**	16.02	80.54	12.88	55.74
29	Japan	**38.06**	24.15	81.83	15.37	53.59
39	United States of America	**41.75**	54.91	73.80	20.38	39.28
49	Russian Federation	**43.39**	44.97	54.00	32.70	52.56
66	Brazil	**47.00**	34.52	78.48	30.70	60.58
96	Kenya	**49.57**	30.39	81.07	34.20	68.02
100	Saudi Arabia	**49.98**	39.14	54.14	43.75	69.13
110	China	**51.53**	52.66	77.03	33.60	60.76
114	Algeria	**52.74**	44.76	67.87	42.56	65.94
115	Nigeria	**52.92**	34.46	64.06	48.21	69.68
117	Venezuela	**54.67**	55.13	63.45	42.27	70.21

[a] GESRI and components: 0=least risk - 100=highest risk
[b] Ranking of countries: 1=least risk - 122=highest risk

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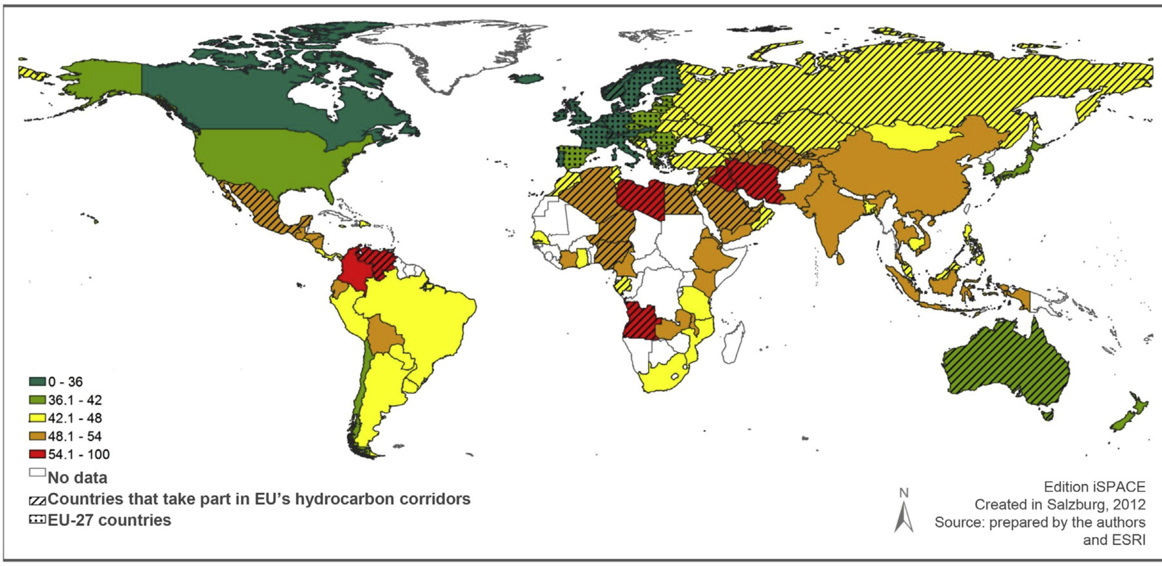

Map 1. World GESRI values and countries that form energy corridors toward the EU-27.

correlated with a lower level of risk. When the economic dimension of energy risk is considered, it can be observed that the developing countries have grown faster in economic and demographic terms than the OECD countries, especially since the beginning of the financial crisis in 2007. Consequently, their energy imports are growing, or their energy exports are being reduced, and the result is an increase in their level of energy risk. The country ordering that reflects the partial estimates for these two risk dimensions is quite similar to the ranking derived from the EU-relations risk, which usually indicates countries with better relations with the EU as having lower levels of socio-political and economic energy risk.

The only dimension that behaves differently is the energy-specific component of geopolitical energy risk, in which risk is closely related to energy dependence. Achieving a low level of risk basically depends on the geographic distribution of energy resources. As expected, the OECD countries present lower economic and socio-political components of energy risk, and a higher energy-specific component of risk; the opposite happens with the OPEC countries, while the less developed countries tend to cluster at the lower end of the energy risk ranking.

As a result, the countries in the top positions of the ranking are those with a high level of economic development and close ties with the EU, in addition to domestic energy resources, such as in the case of Norway (with a GESRI slightly over 30); typical of these high-ranking positions are some of the EU member states, led by the Netherlands and the United Kingdom; and then Switzerland, Canada and Iceland. Those countries without energy resources that have very low values of the GESRI (approximately 35) typically present a high level of risk associated with the energy component that is more than offset by very low levels of risk in the other three risk components.

The energy dependence of Japan results in a high level of the energy-specific risk component, as it does not have any domestic resources.[13] On the other hand, the size of the United States' economy and the magnitude of its energy consumption explain a relatively higher economic risk component, which is somewhat balanced by the lower risk derived from the closer ties of the US with the EU when compared with Japan. The aggregate result indicates that the US (41.8) has a geopolitical energy risk that is 10 per cent higher than Japan's (38.1).

Even though the Russian levels of risk in the socio-political and economic dimensions are very significant, they are more important relative to other countries than in absolute terms. In addition, its energy-specific risk component is quite low (54.0), similar to that of Norway or Saudi Arabia, so that Russia's global level of geopolitical energy risk (43.4) places this country right behind the OECD countries.[14]

Well over the world-average level of risk (GESRI of 44.4), we find other important hydrocarbon exporters such as Saudi Arabia (50.0). Its high levels of the economic, socio-political and EU-relations components of geopolitical energy risk cannot be offset by the low level of energy-specific risk. It might seem strange that Saudi Arabia's GESRI is 15% higher than Russia's. The explanation is to be found in the risk component associated with the relations of both countries with the EU, as Russia's commercial ties with the EU are more developed than those of Saudi Arabia, who is more focused toward Asia (see Refs. [43–45]).

A second, more risky group of hydrocarbon producers comprises Algeria, Nigeria and Venezuela. The latter has a lower level of energy-specific risk by virtue of its heavy crude oil reserves. The situation in Venezuela has been deteriorating during the past decade, and it is clearly visible in the economic and socio-political risk indicators but also in the very high level of risk associated with its estranged relations with the EU (70.2). As a result, Venezuela is ranked in position 117 with a GESRI of 54.7. Nigeria's GESRI is approximately 53 and can be explained by the high level of the socio-political risk component and the lack of relations with the EU. Algeria presents approximately the same aggregated risk level as Nigeria, although with a worse performance of the economic risk component that is, however, offset by better relations with the EU.

[13] See Refs. [37–39] for an in-depth discussion of Japanese energy policy after Fukushima.

[14] The relations between Russia and the EU have been frequently studied from the perspective of European energy security (see Refs. [40–42]).

The emerging economies are represented in Table 3 by Brazil (47.0) and China (51.5), which means that China's geopolitical energy risk is almost 10 per cent higher than Brazil's. All partial risk values for Brazil are intermediate, while China presents a very high absolute level of the economic risk component—due to its high rates of economic and population growth—and a higher level of socio-political risk than Brazil, which could be attributed to the lack of democratic institutions. As a consequence, Brazil appears in position 66 with the first group that follow the OECD countries, while China is found in the lower rungs of the ranking in position 110. The distance between Brazil and China is probably increasing when the development of energy resources in Brazil [46] and the continuous growth of energy demand in China [47] are considered.

Kenya was included in Table 3 as a representative of the Sub-Saharan African countries that are not hydrocarbon producers and therefore have a high level of the energy-specific component of geopolitical energy risk. Kenya's GESRI (49.6) is 7 per cent lower than Nigeria's due to its relatively lower economic risk and, especially, by virtue of its much lower socio-political risk component, which could be interpreted as the result of the "resource curse" suffered by an oil producer such as Nigeria.

As a whole, the GESRI results indicate that advanced economies present a lower level of geopolitical energy risk due to their higher socio-political stability and higher degree of economic development. For instance, if we consider only the economic and socio-political components, the largest oil exporters in2010[15] have a partial risk average (41) that is more than twice as high as the EU-27 average (18) and 30% higher than the OECD average. While advanced economies that possess energy resources are at the top of the ranking, the less developed countries register higher levels of geopolitical energy risk even when they are energy producers. Angola, Libya, Iraq and Iran present the highest risk levels—with GESRI values over 55—of the sample of 122 countries.

4. Conclusions

Traditionally, the assessment of the influence of the geopolitical context on energy security has been subjectively based on expert knowledge with the help of qualitative global policy scenarios. To provide a more objective foundation for the analysis of geopolitical energy risk, this paper builds on previous work to develop and apply a method to quantitatively estimate the energy risk of supply associated with the geopolitical variables.

A country's geopolitical energy risk can be traced back to the economic, political and social factors as well as to other variables specific to the energy sector. The combination of the political and social dimensions in a single risk vector and the introduction of a new component to capture the relations of the exporting and transit countries with the EU-27 are important methodological innovations in relation to our previous work.

The particular difficulty in quantifying the socioeconomic energy risks lies in the lack of variables with a direct relationship with energy supply disruptions. Nonetheless, there are many indirectly related variables that could provide information about the different geopolitical risk dimensions. It was therefore concluded that the most rigorous approach to quantifying geopolitical risk would be to use a combination of these variables to obtain a single specific measure per country associated with each dimension.

Another consideration that guided the selection of an estimation method for geopolitical energy risk was that it should produce indicators that provided cardinal values. Because factor analysis with the principal components method satisfied these requirements with methodological rigour, it was used to estimate the GESRI (Geopolitical Energy Supply Risk Index) and its components.

The GESRI results indicate that advanced economies present a lower level of geopolitical energy risk due to their higher socio-political stability, higher degree of economic development and closer ties with the EU. Although advanced economies that possess energy resources are at the top of the ranking (Norway, The Netherlands and United Kingdom), large resources in less developed countries cannot avoid higher levels of geopolitical energy risk, as a result of high socio-political and economic risks.

For instance, Iraq, Iran, Kuwait, Saudi Arabia and Qatar are some of the countries with the lowest level of energy-specific risks mainly due to their large hydrocarbon reserves and exports; however they are some of the riskiest countries in global terms, being at the bottom of the GESRI ranking with positions 120, 119, 101, 100 and 95, respectively. This is explained by the fact that they have high risk scores in their relations with the EU (especially Iraq and Iran) and they are five of the riskiest countries in terms of socio-political risks, together with Angola, Colombia, Nigeria and Libya.

On the other hand, we have the opposite case in countries with very high energy dependence and high energy-specific risk levels, such as Belgium, Japan, Hungary, Switzerland and Poland, but nevertheless among the 30 least risky countries according to the GESRI classification. All these countries share relatively low levels of economic and socio-political risks, and they belong to, or have strong bonds with, the EU.

With these examples we are trying to convey that GESRI values are not always what one might intuitively expect for certain countries. Our index is a complex indicator, based on four dimensions of the geopolitical energy risk, that combine 47 variables, and therefore the consideration of some of the risk vectors in isolation would lead us to results that could be quite different from those of the GESRI. The richness of the conclusions that can be drawn from our analysis is precisely one of the main contributions of this paper, because it offers a broader and deeper view of the geopolitical energy risk than what might be perceived using a simpler approach.

The GESRI values can be used in different ways when quantitative estimates of geopolitical energy risk are required for energy planning, management and policy-making. First, they can be used as country-specific estimates of geopolitical energy risk to assess the energy security of a country or region as a whole, and its four basic dimensions can be used separately). This breakdown is interesting since the complexity of energy security entails both complementary and contrary energy security objectives; therefore, prioritizing some dimensions (or policy goals) might be necessary [49]. The interpretation of the results presented at the end of section 3 reflects the more straightforward use of the GESRI indicator and its components in this context. An example of the joint use of a geopolitical energy risk indicator with other indicators—in this case the *Energy Affinity Index*—is developed in Marín and Muñoz [50].

However, the geopolitical energy risk index presented here has many other potential applications. This type of indicator could also be used to estimate the geopolitical energy risk for entire energy corridors by aggregating the geopolitical energy risk of the

[15] In decreasing order, Saudi Arabia, Russia, Nigeria, Iran, United Arab Emirates, Iraq, Venezuela, Angola, Norway and Mexico [48]. The last two exporters are OECD members. Most of OECD members are also International Energy Agency (IEA) members, but Mexico is not one of them. Thus some differences can be found regarding energy resources management between an OECD and IEA regular member and Mexico.

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exporting and transit countries (see Refs. [30,51]). Finally, both the country-specific and the corridor GESRI values could be used as the inputs for energy models or scenarios. In fact, we are currently working with such an application as a way of developing this line of research.

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Appendix A. Calculation process and sensitivity analysis

Factor analysis is a multivariate statistical technique that can be used to reduce the number of variables and to detect structures in the relations between them, i.e. to reveal the presence of underlying common factors that expose unobserved dimensions based on the variables' correlations.

The mathematic model in the factor analysis defines each observed variable ($V_1, \ldots, V_i, \ldots, V_n$) as a linear combination of a number of factors or categories, as we call them within the energy risk vectors or dimensions. In this paper we made four different factor analyses, one for each identified dimension of energy risk (economic, energy-specific, socio-political and EU relations dimension). In every single factor analysis one or more factors or categories could be identified. Thus, for n variables and p factors, a variable V_i is defined as:

$$V_i = a_{1i} F_1 + a_{2i} F_2 + a_{3i} F_3 + \ldots + a_{pi} F_p + \varepsilon_i$$

where:

$F_1, F_2, \ldots, F_p$ are the factors common to all the variables.
$a_{1i}, a_{2i}, \ldots, a_{pi}$ are the coefficients of the factors (factor loadings).
ε_i is an independently distributed error term with zero mean and constant variance.

These parameters are initially unknown but are determined by the analysis.

The factors are inferred from the variables. They are estimated as a linear combination of the variables. Factor i is defined as:

$$F_i = b_{1i} V_1 + b_{2i} V_2 + b_{3i} V_3 + \ldots + b_{ni} V_n$$

where $b_{1i}, b_{2i}, \ldots, b_{ni}$ are the coefficients of the variables (known as coefficients of the factor values). However, usually only a group of the observed variables define the factor significantly. For instance:

$$F_1 = b_{2i} V_2 + b_{4i} V_4 + b_{5i} V_5 + b_{7i} V_7$$

where F_1 would be defined as the linear combination of four variables.

Factor analysis aims at estimating the factors and their coefficients based on the correlation between variables (it assumes that two variables highly correlated are defining the same factor).

Our analyses were computationally performed by using the IBM® statistic software SPSS®. The phases in the factor analysis are:

1. Initial examination of the data

We performed an analysis of the primary selection of variables and the correlations among pairs. The descriptive analysis is useful to discard variables with many missing values. Then we analysed the correlation matrix of variables initially selected to find out how they relate to each other and to identify potentially dispensable variables, based on their weak correlation with other variables. The adequacy tests of the sample are used to assess the strength of the relation between the variables. The most common tests are Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity, which are explained in section 3 of the paper.

This is an iterative process. We started from 143 variables (listed in Table B) and progressively excluded variables from the model, in accordance with the criteria mentioned in the preceding paragraph, until we reached some adequate samples. Again, it should be noted that independent factor analyses were performed for each dimension of the geopolitical energy risk (ECO, ENE, SPOL and EU).

Another decision to be made in this phase is how to deal with those cases with no observed values for some variables —in our case, non available data for some variables and countries. There are different ways of dealing with missing data (listwise, pairwise and mean substitution), but only listwise substitution allows to calculate factor values, and therefore that was our choice. This entails that observations with missing values on any of the variables in the analysis are omitted from the analysis, so we could only analyse those cases with valid values for all the variables. This is the reason why we had to reduce our country list down to the final 122 countries.

2. Factor extraction process

We determined the appropriate number of factors in each dimension, based on the goodness-of-fit tests and their explanatory capacity. We used the residuals (the differences between the matrix based on the model and the matrix based on the observed data) to confirm the goodness-of-fit of the model. So before the definitive selection of factors other options were taken into consideration. The residuals of the final model are explained in section 3 of the paper, and the factors or categories are listed in Table 1 and an extended version that includes selected variables and their coefficients is given in Tables C.1–C.4.

In this phase the method of factor extraction must be selected. We chose the most common one, principal components among others such as maximum likelihood, principal axis, unweighted and generalised least squares, alpha factoring and image factoring. With the Principal Components method the factors are calculated by the linear combination of the observed variables (the first factor is the linear combination that explains the higher percentage of the total variance, the second factor is the linear combination with the second largest explained variance, and so on). This method was chosen because it is the only precise way to obtain the coefficients of the factors, while the others are based on estimations.

3. Interpretation of the factor model and factor rotation

In many occasions the factor matrices initially obtained are not easily interpretable. Factor rotation aims to help understand and interpret the factors by transforming the factor matrix in order to obtain a new matrix (rotated factor matrix) where each variable has a high coefficient in a few factors and very low in the others. Thus we can detect more clearly the importance of the variables in the factors and the meaning of the latter can be better interpreted, which allowed us to label all the factors according to the revealed underlying facet of the geopolitical energy risk.

We performed this transformation through the varimax rotation, which is the most common and the most understandable, although other methods were available, such as equamax, quartimax, oblimin and promax. Varimax rotation –as well as equamax and quartimax– provides independent factors with correlations between factors equal to zero, i.e. we obtain orthogonal results. Angular rotation does not affect the variance explained by the model, nor the communalities of the variables, but it does change the eigenvalues, a singular set of scalars associated with a concrete matrix equation. The final rotated factor matrices are presented in Appendix C, Tables C.1–C.4.

4. Obtaining the factor values

Once we chose the most suitable factor models (one for each dimension), we obtained the factor coefficients that led us to calculate the value of each factor for every country.

There are three methods to save the factors as new variables in SPSS: regression, Barlett and Anderson Rubin. The most popular one, in line with the mathematical model described above, is the regression, where each factor is calculated as the linear combination of the original variables. The mathematical expression of the value of the factor j for a country i is:

$$F_j = b_{1j}\, V_{1i} + b_{2j}\, V_{2i} + b_{3j}\, V_{3i} + \ldots + b_{nj}\, V_{ni}$$

where b_{1j}, b_{2j}, …, b_{nj} are the coefficients of factor values that combine the variables V_{1i}, V_{2i}, …, V_{ni}, which in turn are the standardised values of the variables for country i.

The new variables (representing the final factors in our paper) are standardized by default when saved, so they are called Z-scores (the mean of the new variables is zero and their standard deviation is one). Therefore they have the same scale and can be compared and aggregated.

5. Computing the composite index

After changing the factors (Z-scores) into a scale 0–100, we aggregated the corresponding factors in each dimension (ECO, ENE, SPOL and EU) and, subsequently, these four dimensions into a single composite indicator, the GESRI (Geopolitical Energy Supply Risk Index), as explained in the paper. These results are presented in Appendix C, Table C.5.

6. Sensitivity analysis

Factor analysis entails iterative processes in which different models are tested. This means that, along the calculation process, we analysed several potential solutions based on different combination of variables. We discarded variables for technical reasons (too many missing values, insignificant correlation with other variables, unsatisfactory results in the adequacy tests and in the goodness-of-fit of the model…) but also based on theoretical reasons (the ability of the factor models to be interpretable in a meaningful way). Therefore, a sensitivity analysis only seems to make sense for the aggregation process of the energy risk vectors.

We explained in the main body of the paper our decision of giving 40% weight to the socio-political dimension, and 20% to the others –economy, energy and EU relations. However, even when backed by some objective reasons, the aggregation of indicators into a composite one can always be subject to criticism and doubts can be voiced about what the result would have been with a different aggregation method. This is the reason why we performed a sensitivity analysis comparing the GESRI scores with the indicator that would result from the aggregation of the four dimensions by simple average, i.e. adding the four vectors with equal weights (25% each).

As showed below in the Table A.1, the differences between both indicators are not remarkable and point to a clear conclusion: If we assign equal weights to all the factors, the geopolitical energy risk scores increase in all countries, on average (4 points in a 0–100 scale) but also the minimum and the maximum values.

Table A.1
Descriptive statistics of different aggregation alternatives.

	Weighted average aggregation (GESRI)	Simple average aggregation	Difference
Minimum value	30.16	33.53	3.37
Maximum value	59.83	61.15	1.31
Average value	44.41	48.64	4.23
Standard deviation	6.70	6.36	−0.34

This means that giving more importance to the socio-political dimension has contributed to reduce the risk scores, which is a more conservative approach. This is explained by the fact that the other factors, especially the one that is specifically related to the energy sector, have higher risk scores than the socio-political factor.

In short, we are aggregating vectors with the same scale but with different distributions, and the distributions of the energy-specific and the economic dimension are more concentrated on higher values, which produce a significant increase in country risk scores.

In our opinion this result confirms the necessity of giving more weight to the socio-political dimension to avoid underestimating this important aspect of the geopolitical energy risk. We also considered some selected countries to compare the GESRI values with the results of the simple average aggregation of the four factors, as shown in Table A.2.

Table A.2
Country results by aggregation method.

Countries	Weighted average aggregation (GESRI)	Simple average aggregation	Difference
Norway	30.15	33.53	3.4
Canada	34.88	38.76	3.9
Hungary	36.20	40.88	4.7
Poland	36.78	41.36	4.6
Russian Federation	43.39	46.06	2.7
Brazil	47.00	51.07	4.1
Qatar	49.35	50.67	1.3
Kenya	49.57	53.42	3.9
Saudi Arabia	49.98	51.54	1.6
Kuwait	50.38	52.22	1.8
Algeria	52.74	55.28	2.5
Nigeria	52.92	54.10	1.2
Venezuela	54.67	57.77	3.1

Global risk scores increased for all countries with the alternative aggregation method, but the differences are lower in the case of countries with very high socio-political risks (above 43) such as Nigeria (1.2), Qatar (1.3), Saudi Arabia (1.6) and Kuwait (1.8), than in countries with low socio-political risk scores (below 19) like Hungary (4.7) and Poland (4.6). On the other hand, Nigeria, Qatar, Saudi Arabia and Kuwait have relatively low energy-specific risk values (57 on average), while Hungary and Poland have extremely high energy-specific risk scores (above 80). Similar conclusions can be reached for other countries, but these extreme cases better evidence the effects of using different aggregation methods and the importance of the distribution of the partial risk factors in the aggregation process.

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Appendix B. Inputs for the factor analysis

Table B
Variables, units and data sources used in the factor analyses.

Dimension	Variable	Nr of countries with data	Period	Unit	Source
ECO[a]	Country Risk Classifications -OECD	156	04/09 – 12/10	0 – 7 (7 = lowest risk)	[54]
ECO	Dry Natural Gas Consumption (%)	218	2000–2010	Percentage	[59]
ECO	Dry Natural Gas Consumption (Billion Cubic Feet)	218	2000–2010	Billion Cubic Feet	[59]
ECO[a]	Ease of Doing Business Rank	156	2010/11	Ranking 1–183 (183 = most difficult)	[55]
ECO[a]	Economic risk rating ICRG	135	02/10 – 01/11	Scale 0 – 50 (50 = lowest risk)	[56]
ECO	Energy production (kt of oil equivalent)	131	2000–2010	ktoe	[58]
ECO[a]	Energy use (kg of oil equivalent per capita)	142	2000–2010	kgoe per capita	[58]
ECO	Energy use (kg of oil equivalent) per $1000 GDP (constant 2005 PPP)	142	2000–2010	kgoe per $1000 GDP (constant 2005 PPP)	[58]
ECO	Energy use (kt of oil equivalent)	140	2000–2010	ktoe	[58]
ECO	Financial risk rating ICRG	135	02/10 – 01/11	Scale 0 – 50 (50 = lowest risk)	[56]
ECO	Fossil fuel energy consumption	142	2000–2010	Percentage of total	[58]
ECO[a]	Fuel Taxation/Subsidiation. Diesel	161	nov-08	Percentage per litre	[61]
ECO[a]	Fuel Taxation/Subsidiation. Gasoline	161	nov-08	Percentage per litre	[61]
ECO[a]	GDP based on PPP	184	2000–2010	Billions, current international dollar	[57]
ECO	GDP Growth Rate	159	2000–2010	Percentage	[53]
ECO	GDP per capita	159	2000–2010	Dollar	[53]
ECO	GDP per capita based on PPP	158	2000–2010	Current international dollar	[57]
ECO	GDP per unit of energy use (constant 2005 PPP $ per kg of oil equivalent)	140	2000–2010	Constant 2005 PPP $ per kgoe	[58]
ECO	GDP per unit of energy use (PPP $ per kg of oil equivalent)	140	2000–2010	PPP $ per kgoe	[58]
ECO	GDP, constant prices	158	2000–2010	Percentage	[57]
ECO[a]	Global Competitiveness Index	142	2010	Scores 1 – 7 (7 = higest competit.)	[52]
ECO[a]	Index of Economic Freedom	184	2010	0 – 100 (100 = highest freedom)	[53]
ECO[a]	Inflation rate, consumer prices	158	2000–2010	Percent change	[57]
ECO	Population	160	2010	Millions	[53]
ECO	Population growth rate 2000–2010	161	2000–2010	Percentage	[87]
ECO	Population growth rate 2000–2025	161	2000–2025	Percentage	[87]
ECO	Population growth rate 2010–2025	161	2010–2025	Percentage	[87]
ECO	Retail Prices of Diesel/Retail price of diesel in USA	161	nov-08	Ratio (>0)	[61]
ECO	Retail Prices of Super Gasoline/Retail price of gasoline in USA	161	nov-08	Ratio (>0)	[61]
ECO[a]	Total Petroleum & Dry Natural Gas Consumption	218	2000–2010	Percentage	[59]
ECO	Total Petroleum Consumption (%)	218	2000–2010	Percentage	[59]
ECO	Total Petroleum Consumption (Thousand Barrels Per Day)	218	2000–2010	Thousand Barrels per Day	[59]
ECO[a]	Total population, both sexes combined	263	2010	Thousands	[60]
ENE	Connectivity: number of times a country takes part in a international corridor (captives & open sea)	91	2005 – 2020	Number of times	[83]
ENE[a]	Crude Oil & Dry Natural gas net imports as a percentage of Total Petroleum & Dry Natural Gas Consumption	218	2000–2010	Percentage	[59]
ENE	Crude Oil including Lease Condensate Net imports/ Total Petroleum Consumption	218	2000–2010	Percentage	[59]
ENE	Crude Oil Proved Reserves (%)	224	2010	Percentage	[59]
ENE	Crude Oil Proved Reserves (Billion Barrels)	224	2010	Billion Barrels	[59]
ENE	Crude petroleum oils exports as percentage of total exports [SITC rev.3 code 333]	140	2000–2010	Percentage	[82]
ENE	Crude petroleum oils imports as percentage of total imports [SITC rev.3 code 333]	173	2000–2010	Percentage	[82]
ENE	Dry Natural Gas Net imports/Consumption	218	2000–2010	Percentage	[59]
ENE	Energy Affinity Index (crude oil & natural gas)	160	2000–2008	Scale -100 – 100 (100 = highest affinity)	[50]
ENE	Energy imports, net (% of energy use)	161	2000–2010	Percentage	[58]
ENE	Exports of Crude Oil including Lease Condensate (%)	224	2000–2010	Percentage	[59]
ENE	Exports of Crude Oil including Lease Condensate (Thousand Barrels Per Day)	224	2000–2010	Thousand Barrels Per Day	[59]
ENE[a]	Exports of Crude Oil including Lease Condensate and Dry Natural Gas as percentage of total exports	224	2000–2010	Percentage	[59]
ENE	Exports of Dry Natural Gas (%)	224	2000–2010	Percentage	[59]
ENE	Exports of Dry Natural Gas (Billion Cubic Feet)	224	2000–2010	Billion Cubic Feet	[59]
ENE	Exports of Natural gas [SITC rev.3 code 343]	187	2000–2010	Current dollar	[82]
ENE		154	2000–2010	Current dollar	[82]

(continued on next page)

Table B (*continued*)

Dimension	Variable	Nr of countries with data	Period	Unit	Source
	Exports of Petroleum oils, crude & Natural Gas [SITC rev.3 codes 333, 343]				
ENE	Exports of Petroleum oils, crude & Natural Gas as percentage of total exports [SITC rev.3 codes 333, 343]	154	2000–2010	Percentage	[82]
ENE	Exports of Petroleum oils, crude [SITC rev.3 code 333]	140	2000–2010	Current dollar	[82]
ENE	Gross Natural Gas Production (%)	224	2000–2010	Percentage	[59]
ENE	Gross Natural Gas Production (Billion Cubic Feet)	224	2000–2010	Billion Cubic Feet	[59]
ENE	Herfindahl-Hirschman Index of Gas Imports	152	2005 & 2010	Range 0 – 1 (1 = highest diversity)	[82]
ENE	Herfindahl-Hirschman Index of Oil & Gas Imports	152	2005 & 2010	Range 0 – 1 (1 = highest diversity)	[82]
ENE	Herfindahl-Hirschman Index of Oil Imports	152	2005 & 2010	Range 0 – 1 (1 = highest diversity)	[82]
ENE	Imports of Crude Oil including Lease Condensate (%)	224	2000–2010	Percentage	[59]
ENE	Imports of Crude Oil including Lease Condensate (Thousand Barrels Per Day)	224	2000–2010	Thousand Barrels Per Day	[59]
ENE	Imports of Crude Oil including Lease Condensate and Dry Natural Gas as percentage of total imports	224	2000–2010	Percentage	[59]
ENE	Imports of Dry Natural Gas (%)	224	2000–2010	Percentage	[59]
ENE	Imports of Dry Natural Gas (Billion Cubic Feet)	224	2000–2010	Billion Cubic Feet	[59]
ENE	Imports of Petroleum oils, crude & Natural Gas [SITC rev.3 codes 333, 343]	188	2000–2010	Current dollar	[82]
ENE	Imports of Petroleum oils, crude & Natural Gas as percentage of GDPppp [SITC rev.3 codes 333, 343]	172	2000–2010	Percentage	[57,82]
ENE	Imports of Petroleum oils, crude & Natural Gas as percentage of total imports [SITC rev.3 code 333, 343]	188	2000–2010	Current dollar	[82]
ENE	Imports. Natural gas [SITC rev.3 code 343]	187	2000–2010	Current dollar	[82]
ENE	Imports. Petroleum oils, crude [SITC rev.3 code 333]	173	2000–2010	Current dollar	[82]
ENE	Natural gas exports as percentage of total exports [SITC rev.3 code 343]	187	2000–2010	Percentage	[82]
ENE	Natural gas imports as percentage of total imports [SITC rev.3 code 343]	187	2000–2010	Percentage	[82]
ENE	Natural Gas self-sufficiency	218	2000–2010	Percentage	[59]
ENE	Net Exports of Petroleum oils, crude & Natural Gas [SITC rev.3 codes 333, 343]	189	2000–2010	Current dollar	[82]
ENE[a]	Net Exports of petroleum oils, crude & Natural Gas as percentage of GDPppp [SITC rev.3 codes 333, 343]	172	2000–2010	Percentage	[82,57]
ENE	Net imports of Crude Oil including Lease Condensate (Thousand Barrels Per Day)	224	2000–2010	Thousand Barrels per Day	[59]
ENE	Net imports of Dry Natural Gas (Billion Cubic Feet)	224	2000–2010	Billion Cubic Feet	[59]
ENE	Oil & Natural gas self-sufficiency	218	2000–2010	Percentage	[59]
ENE	Oil self-sufficiency	218	2000–2010	Percentage	[59]
ENE	Petroleum oils, crude & Natural Gas net exports as percentage of total exports [SITC rev.3 codes 333, 343]	189	2000–2010	Percentage	[82]
ENE[a]	Production of Crude Oil including Lease Condensate & Gross Natural Gas (%)	218	2000–2010	Percentage	[59]
ENE	Production of Crude Oil including Lease Condensate (%)	218	2000–2010	Percentage	[59]
ENE	Production of Crude Oil including Lease Condensate (Thousand Barrels Per Day)	218	2000–2010	Thousand Barrels per Day	[59]
ENE[a]	Proved Reserves of Crude Oil and Natural Gas (%)	224	2010	Percentage	[59]
ENE	Proved Reserves of Natural Gas (%)	222	2010	Percentage	[59]
ENE	Proved Reserves of Natural Gas (Trillion Cubic Feet)	222	2010	Trillion Cubic Feet	[59]
ENE[a]	Reserves/production ratio: Crude oil	222	2010	Years	[59]
ENE[a]	Reserves/production ratio: Natural gas	224	2010	Years	[59]
SPOL	Armed conflicts by primary country	69	1990–2010	Number of years	[84]
SPOL	Cases of injury with lost workdays	94	2000–2008	Total cases	[85]
SPOL	Civil Liberties	163	2000–2010	Scale 1 – 7 (7 = less freedom)	[67]
SPOL[a]	Civil Liberties & Political Rights	163	2000–2010	Scale 1 – 7 (7 = less freedom)	[67]
SPOL	Combined Polity Score	166	2000–2010	Scale −10 to 10 (10 = strongly democratic)	[86]
SPOL[a]	Composite country risk ranking ICRG	136	02/10 – 01/11	Scale 0 – 100 (100 = lowest risk)	[56]
SPOL	Control of Corruption	161	2000–2010	Scale −2.5 to 2.5 (higher values = better governance)	[62]
SPOL[a]	Coup d'état event	75	1990–2010	Number of coups during the period	[71]
SPOL[a]	Ethnic Fractionalization	161	2000–2010	Scale 0 – 1 (1 = highest fractionalization)	[63]
SPOL[a]	Failed States Index	161	2004–2010	Scale of 0–120 (120 = highest intensity, least stable)	[63,64]
SPOL	Global Peace Index	153	2010	Scale 1–5 (5 = less peace)	[68]

Table B (*continued*)

Dimension	Variable	Nr of countries with data	Period	Unit	Source
SPOL	Government Effectiveness	161	2000–2010	Scale −2.5 to 2.5 (higher values = better governance)	[62]
SPOL	Happy Planet Index (HPI)	143	2005	Scale 0–100 (10 = highest happiness)	[88]
SPOL	Health-adjusted life expectancy at birth	160	2007	Years	[65]
SPOL	High Casualty Terrorist Bombings	34	2000–2010	Total number of deaths during the period	[89]
SPOL[a]	Human Development Index	160	2000, /05, /10	Scale 0 − 1 (1 = better)	[65]
SPOL	ICRG Indicator of Quality of Government	137	2000–2010	Scale 0 − 1 (1 = best quality of government)	[63]
SPOL	Income Gini coefficient	119	2000–2011	Scale 0–100 (100 = highest inequality)	[65]
SPOL[a]	Index of Democracy	167	2010	Scale 0–10 (10 = highest level of democracy)	[66]
SPOL[a]	Inequality: Quintile income ratio	142	2000–2011	Ratio (>1) 1 mín. desigualdad	[65]
SPOL	Mean years of schooling	160	2011	Years	[65]
SPOL	Multidimensional Poverty Index	109	2000–2010	Scale 0–1 (1 = highest poverty)	[65]
SPOL	Net migration rate - Medium variant	231	2000–2010	Net number of migrants per 1000 population	[87]
SPOL[a]	Number of Internally Displaced Persons (Sum)	163	2000–2010	Total number	[70]
SPOL[a]	Number of Refugees -By origin (Sum)	163	2000–2010	Total number	[70]
SPOL[a]	OPEC members	12	2010	Dummy (0,1)	[73]
SPOL	Political rights	163	2000–2010	Scale 1 − 7 (7 = less freedom)	[67]
SPOL	Political Risk Rating ICRG	136	02/10 − 01/11	Scale 0 − 100 (100 = lowest risk)	[56]
SPOL[a]	Political Stability and Absence of Violence/ Terrorism	161	2000–2010	Scale −2.5 to 2.5 (higher values = better governance)	[62]
SPOL	Population below income poverty line, PPP $ 1.25 a day	111	2000–2009	Percentage	[65]
SPOL[a]	Regulatory Quality	161	2000–2010	Scale −2.5 to 2.5 (higher values = better governance)	[62]
SPOL[a]	Relations with neighbouring countries	153	2010	Ranked 1–5 (5 = worst relations)	[33,68]
SPOL	Religious Fractionalization	161	2000–2010	Scale 0 − 1 (1 = highest fractionalization)	[63]
SPOL	Rule of Law	161	2000–2010	Scale −2.5 to 2.5 (higher values = better governance)	[62]
SPOL[a]	State ownership in the 50 major oil & gas companies	30	2009	Percentage	[72]
SPOL[a]	Terrorism incidents: all kind (all)	159	2000–2010	Total number	[69]
SPOL	Terrorism incidents: all kind (terrorists)	22	2000–2010	Total number	[69]
SPOL	Terrorism incidents: Facility/Infrastructure Attack (1 = Business, 9 = Food or Water Supply, 11 = Maritime, 17 = Terrorists, 19 = Transportation, 21 = Utilities)	53	2000–2010	Total number	[69]
SPOL[a]	Terrorism incidents: Facility/Infrastructure Attack (11 = Maritime, 21 = Utilities)	53	2000–2010	Total number	[69]
SPOL	Terrorism incidents: Facility/Infrastructure Attack (all)	96	2000–2010	Total number	[69]
SPOL	Unemployment (%)	144	2010	Percentage	[53]
SPOL	Voice and Accountability	161	2000–2010	Scale −2.5 to 2.5 (higher values = better governance)	[62]
SPOL	Well-being, Overall life satisfaction	111	2006–2010	Scale 0 − 10 (10 = most satisfied)	[65]
EU[a]	EU's imports of Petroleum oils, oils from bitumin. materials, crude & Natural gas, whether or not liquefied	122	2000–2010	Thousands of dollars	[74,82]
EU[a]	Exports to the EU-27 Total all products (%)	220	2000–2010	Percentage	[74]
EU	Exports to the EU-27 Total all products (Thousands of dollars)	220	2000–2010	Thousands of dollars	[74]
EU[a]	FDI inward flows in the EU-21 by partner country	307	2000–2010	US dollars	[81]
EU[a]	FDI outward flows of the EU-21 by partner country	307	2000–2010	US dollars	[81]
EU[a]	Level of association with EU	199	2011	Scale 0–8 (8 = strongest association)	[75,76, 77,78]
EU[a]	Level of commitment to the Energy Charter	170	31/12/2010	Scale 0 − 4 (4 = strongest commitment)	[80]
EU[a]	Merchandise trade complementarity: EU-27	220	2000–2010	Scale 0 − 1 (1 = perfect match in the trade pattern between countries)	[74]
EU	The Affinity of Nations (gartzke_s2un plus interpolated values for missing)	195	2000–2008	−1 to 1 (1 = most similar interests)	[79]
EU	The Affinity of Nations (gartzke_s3un plus interpolated values for missing)	195	2000–2008	−1 to 1 (1 = most similar interests)	[79]
EU[a]	The Affinity of Nations (Three category voting data: 1 = yes, 2 = abstain, 3 = no)	195	2000–2008	−1 to 1 (1 = most similar interests)	[79]
EU	The Affinity of Nations (Two category voting data: 1 = yes, 3 = no)	195	2000–2008	−1 to 1 (1 = most similar interests)	[79]
EU[a]	Total number of bilateral and multilateral energy related treaties with the EU	147	2011	Total number	[78]
EU[a]	Total number of bilateral and multilateral treaties with the EU	203	2011	Total number	[78]
EU[a]	Total number of bilateral trade treaties with the EU	71	2011	Total number	[78]

[a] Selected variable in the factor analysis.

Appendix C. Results of the factor analyses

Table C.1
Rotated factor matrix of the economic vector of energy risk.

Variables	Categories in the economic vector of energy risk: Freedom and economic stability	Size of the economy and energy consumption	Fiscal policy on energy	Relation of the variable with the energy risk
Global Competitiveness Index [52]	0.91	0.20	0.07	- Relation
Index of Economic Freedom [53]	0.87	-0.05	0.23	- Relation
Country Risk Classifications [54]	-0.86	-0.16	-0.17	+ Relation
Ease of Doing Business Rank [55]	-0.83	-0.02	-0.23	+ Relation
Economic Risk Rating ICRG [56]	0.63	0.09	-0.50	- Relation
Inflation rate, Average Consumer Prices [57]	-0.57	-0.03	-0.08	+ Relation
Energy use (kt of oil equivalent) [58]	0.11	0.98	-0.02	+ Relation
GDP based on PPP [57]	0.17	0.96	0.03	+ Relation
Total Petroleum & Dry Natural Gas Consumption (%) [59]	0.14	0.90	-0.05	+ Relation
Total population, both sexes combined [60]	-0.08	0.69	-0.05	+ Relation
Fuel Taxation/Subsidiation. Diesel [61]	0.24	-0.03	0.93	- Relation
Fuel Taxation/Subsidiation.Gasoline [61]	0.29	-0.03	0.92	- Relation

Table C.2
Rotated factor matrix of the energy-specific vector of energy risk.

Variables	Categories in the energy-specific vector of energy risk: Production and exporting capacity of oil and gas	Duration of oil and gas reserves	Net trade in oil and gas in relative terms	Relation of the variable with the energy risk
Production of Crude Oil & Gross Natural Gas (%) [59]	0.93	0.15	0.08	- Relation
Crude Oil & Natural Gas net exports (% of total exports) [59]	0.89	0.21	0.26	- Relation
Proved Reserves of Crude Oil and Natural Gas (%) [59]	0.75	0.60	0.06	- Relation
Reserves/ production ratio: Natural gas [59]	0.18	0.85	0.25	- Relation
Reserves/ production ratio: Crude oil [59]	0.26	0.83	0.18	- Relation
Crude Oil & Dry Natural Gas net imports (% of Total Petroleum & Dry Natural Gas Consumption) [59]	-0.14	-0.10	-0.96	+ Relation
Crude Oil & Natural Gas net exports (% of GDP based on PPP) [59]	0.18	0.50	0.79	- Relation

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Table C.3
Rotated factor matrix of the socio-political vector of energy risk.

Variables	Categories in the socio-political vector of energy risk: Socio-political stability and institutional quality	Political and social violence	Market power	Social diversity and inequality	Relation of the variable with the energy risk
Regulatory Quality [62]	0.90	-0.12	-0.19	-0.15	- Relation
Failed States Index [63, 64]	-0.87	0.24	0.08	0.25	+ Relation
Human Development Index [65]	0.83	-0.11	0.15	-0.30	- Relation
Index of Democracy [66]	0.82	0.04	-0.46	-0.05	- Relation
Composite country risk ranking ICRG [56]	0.78	-0.08	0.27	0.06	- Relation
Civil Liberties & Political Rights [67]	-0.77	0.06	0.49	0.04	+ Relation
Political Stability and Absence of Violence/Terrorism [62]	0.72	-0.46	-0.07	-0.21	- Relation
Relations with Neighbouring Countries [33, 68]	-0.66	0.08	0.32	-0.27	+ Relation
Terrorism incidents: all kind [69]	-0.09	0.89	0.11	-0.11	+ Relation
Terrorism incidents: Facility/Infrastructure Attack (Maritime & Utilities) [69]	-0.04	0.87	0.06	0.12	+ Relation
Number of Refugees (by origin) [70]	-0.17	0.77	0.10	0.03	+ Relation
Number of Internally Displaced Persons [70]	-0.06	0.76	0.09	0.22	+ Relation
Coup d'état event [71]	-0.40	0.44	0.05	-0.01	+ Relation
Average state ownership in the 50 major oil companies [72]	-0.10	0.18	0.85	0.00	+ Relation
OPEC members [73]	-0.07	0.13	0.80	0.23	+ Relation
Inequality: Quintile income ratio [65]	0.00	0.21	0.13	0.84	+ Relation
Ethnic Fractionalization [63]	-0.42	-0.04	0.11	0.64	+ Relation

Table C.4
Rotated factor matrix of the EU-relations vector of energy risk.

Variables	Categories in the EU-relations vector of energy risk			Relation of the variable with the energy risk
	Level of political association with the EU	FDI flows with the EU and EU's energy imports	Trade relations and treaties with the EU	
Exports to the EU-27 Total all products (%) [74]	0.90	0.18	0.06	- Relation
Level of association with EU-27 [75, 76, 77, 78]	0.84	0.18	0.41	- Relation
The Affinity of Nations (UN voting data) [79]	0.77	-0.01	0.48	- Relation
Level of commitment to the Energy Charter [80]	0.73	0.11	0.41	- Relation
Bilateral and multilateral treaties with the EU-27 [78]	0.67	0.38	0.56	- Relation
FDI inward flows in the EU-21 by partner country [81]	0.11	0.91	0.22	- Relation
FDI outward flows of the EU-21 by partner country [81]	0.07	0.90	0.32	- Relation
EU-27's imports of Petroleum oils, crude & Natural gas [74, 82]	0.20	0.78	0.11	- Relation
Merchandise trade complementarity: EU-27 [74]	0.26	0.38	0.78	- Relation
Bilateral trade treaties with the EU-27 [78]	0.38	0.25	0.75	- Relation
Bilateral and multilateral energy related treaties with the EU-27 [78]	0.50	0.28	0.70	- Relation

Table C.5
The Geopolitical Energy Supply Risk Index (GESRI) and its components.

Ranking [b]	Countries	GESRI [a,c]	Components			
			ECO	ENE	SPOL	EU
1	Norway	**30.15**	13.23	57.27	16.67	46.94
2	The Netherlands	**30.19**	15.59	78.87	14.74	27.02
3	United Kingdom	**31.74**	13.51	78.06	16.81	33.53
4	Germany	**32.01**	18.42	80.81	16.07	28.67
5	Denmark	**32.26**	11.31	78.49	13.69	44.14
6	Sweden	**32.37**	12.95	82.02	13.42	40.04
7	Ireland	**32.91**	10.03	81.31	14.27	44.67
8	France	**33.43**	19.65	81.76	16.53	32.69
9	Finland	**33.67**	14.42	82.14	13.64	44.48
10	Belgium	**33.88**	17.40	82.42	18.92	31.74
11	Luxemburg	**34.12**	16.85	80.94	17.82	37.16
12	Austria	**34.43**	15.69	81.41	16.39	42.26
13	Switzerland	**34.55**	11.64	81.35	17.77	44.20
14	Canada	**34.88**	23.84	62.48	19.36	49.37
15	Portugal	**35.29**	16.95	81.87	16.67	44.29
16	Malta	**35.61**	14.89	80.54	15.60	51.40
17	Iceland	**35.61**	16.02	80.54	12.88	55.74
18	Slovakia	**35.66**	13.95	82.45	17.91	46.08
19	Italy	**35.95**	20.96	82.01	18.93	38.91
20	Czech Republic	**36.01**	17.49	81.75	17.32	46.16
21	Hungary	**36.20**	18.72	81.78	17.48	45.54
22	Spain	**36.34**	20.83	81.82	19.18	40.66
23	Slovenia	**36.37**	20.29	81.08	17.30	45.84
24	Cyprus	**36.72**	18.79	80.84	18.62	46.74
25	Australia	**36.75**	21.07	75.58	15.05	56.98
26	Poland	**36.78**	21.42	80.35	18.46	45.19
27	Greece	**37.11**	22.11	81.92	17.87	45.76
28	Estonia	**37.63**	18.81	81.04	20.29	47.73

29	Japan	**38.06**	24.15	81.83	15.37	53.59
30	Lithuania	**38.36**	20.40	83.68	19.63	48.46
31	New Zealand	**38.82**	20.40	80.92	16.83	59.11
32	Korean Republic	**38.84**	18.78	82.56	17.50	57.85
33	Latvia	**39.02**	22.68	81.16	21.92	47.46
34	Romania	**39.54**	25.90	81.26	21.11	48.30
35	Chile	**39.87**	23.53	79.45	16.63	63.10
36	Bulgaria	**40.02**	22.06	82.63	23.24	48.93
37	Croatia	**40.35**	23.53	81.62	21.83	52.91
38	Albania	**41.43**	24.02	80.46	23.35	55.94
39	United States of America	**41.75**	54.91	73.80	20.38	39.28
40	Montenegro	**41.89**	25.07	80.54	21.22	61.42
41	Israel	**42.07**	14.47	81.60	24.21	65.85
42	Turkey	**42.50**	22.74	81.46	27.58	53.17
43	Uruguay	**42.56**	25.56	81.77	19.85	65.78
44	Singapore	**42.66**	18.34	83.48	23.19	65.13
45	Macedonia, TFYR	**42.95**	23.53	81.87	27.28	54.76
46	Mongolia	**43.06**	24.39	80.46	23.04	64.39
47	Serbia	**43.10**	30.42	81.89	23.21	56.75
48	Armenia	**43.15**	25.21	81.23	24.41	60.50
49	Russian Federation	**43.39**	44.97	54.00	32.70	52.56
50	Ukraine	**43.72**	38.62	79.48	24.69	51.13
51	Costa Rica	**43.95**	26.86	80.78	22.51	67.08
52	Bosnia and Herzegovina	**44.72**	29.23	81.20	28.22	56.75
53	Tunisia	**44.92**	29.01	80.13	26.54	62.38
54	Moldavia	**44.95**	31.04	81.43	26.93	58.41
55	Georgia	**45.22**	23.34	81.11	30.26	61.13
56	Oman	**45.43**	34.19	66.39	28.59	69.37
57	Malaysia	**45.89**	22.46	75.62	32.99	65.38
58	Kazakhstan	**46.20**	32.99	68.94	33.96	61.16
59	Argentina	**46.31**	42.50	78.71	24.55	61.24
60	El Salvador	**46.35**	31.19	80.94	25.39	68.84
61	Jamaica	**46.38**	31.58	81.08	24.50	70.24
62	Peru	**46.62**	26.04	79.56	30.15	67.19
63	Panama	**46.64**	30.89	80.94	27.60	66.19
64	Mozambique	**46.77**	28.53	74.91	30.62	69.17
65	Belarus	**46.82**	34.47	83.38	28.29	59.67
66	Brazil	**47.00**	34.52	78.48	30.70	60.58
67	Morocco	**47.26**	31.20	81.60	29.82	63.85

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68	Tanzania	**47.27**	28.25	80.53	29.36	68.87
69	Trinidad and Tobago	**47.28**	38.34	76.41	25.80	70.07
70	Senegal	**47.33**	29.69	81.19	28.36	69.07
71	Ghana	**47.50**	32.57	81.45	27.43	68.62
72	South Africa	**47.53**	35.05	81.44	30.47	60.20
73	Gabon	**47.54**	35.82	67.83	31.31	71.44
74	Paraguay	**47.58**	31.98	80.56	27.86	69.62
75	Dominican Republic	**47.68**	32.99	81.32	27.51	69.06
76	Philippines	**47.77**	35.60	80.02	28.34	66.53
77	Cambodia	**47.84**	33.61	80.55	27.94	69.15
78	Jordan	**47.89**	32.78	82.76	29.22	65.48
79	Bangladesh	**47.92**	39.26	80.20	25.98	68.18
80	Viet Nam	**48.10**	35.57	78.06	29.35	68.15
81	Sri Lanka	**48.10**	34.36	80.99	28.37	68.40
82	Kirghiz Republic	**48.27**	33.07	81.11	30.83	65.52
83	Azerbaijan	**48.40**	36.27	72.24	35.23	63.01
84	United Arab Emirates	**48.41**	30.67	60.03	43.01	65.30
85	Mexico	**48.45**	36.44	76.74	33.12	62.82
86	Zambia	**48.58**	23.67	81.16	33.37	71.33
87	Thailand	**48.71**	31.63	81.23	32.87	64.92
88	Tajikistan	**48.82**	35.85	81.01	30.96	65.30
89	Malawi	**48.83**	34.39	80.17	29.15	71.28
90	Turkmenistan	**48.83**	45.45	68.68	31.29	67.45
91	Djibouti	**48.88**	35.71	80.54	29.15	69.88
92	Guatemala	**48.99**	32.81	80.37	32.24	67.29
93	Nicaragua	**49.05**	34.88	81.30	30.11	68.86
94	Niger	**49.17**	35.14	80.54	30.45	69.25
95	Qatar	**49.35**	35.99	53.69	44.05	68.94
96	Kenya	**49.57**	30.39	81.07	34.20	68.02
97	Yemen	**49.59**	46.03	72.78	28.89	71.37
98	Cameroon	**49.75**	34.10	76.67	35.22	67.52
99	Egypt	**49.78**	43.65	77.45	32.06	63.70
100	Saudi Arabia	**49.98**	39.14	54.14	43.75	69.13
101	Kuwait	**50.38**	39.10	57.95	43.02	68.82
102	Indonesia	**50.67**	43.64	75.48	35.07	64.10
103	India	**50.69**	49.24	79.04	30.79	63.60
104	Honduras	**50.73**	34.70	80.54	34.50	69.40
105	Pakistan	**50.83**	38.72	79.84	34.45	66.71
106	Bahrain	**50.84**	36.28	87.34	30.42	69.76
107	Ethiopia	**50.86**	36.26	80.53	33.04	71.41

108	Eritrea	**50.94**	40.63	80.54	32.04	69.47
109	Bolivia	**51.33**	42.86	75.53	35.10	68.05
110	China	**51.53**	52.66	77.03	33.60	60.76
111	Uzbekistan	**51.70**	42.29	77.41	36.45	65.91
112	Syria	**51.81**	40.86	76.99	37.77	65.65
113	Ivory Coast	**52.12**	33.21	81.55	38.19	69.46
114	Algeria	**52.74**	44.76	67.87	42.56	65.94
115	Nigeria	**52.92**	34.46	64.06	48.21	69.68
116	Ecuador	**53.74**	46.97	76.21	38.19	69.16
117	Venezuela	**54.67**	55.13	63.45	42.27	70.21
118	Colombia	**54.89**	30.68	78.91	48.95	66.94
119	Iran	**55.14**	53.43	59.86	46.21	70.02
120	Iraq	**56.27**	43.52	54.80	55.58	71.85
121	Libya	**58.06**	57.79	70.60	47.30	67.33
122	Angola	**59.84**	55.03	63.33	54.58	71.65

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