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

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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.

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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 system of energy supply corridors³ 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].
- 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

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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]. IASA'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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