Energy Economics 117 (2023) 106441

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneeco

Elusive effects of export embargoes for fossil energy resources

Kai A. Konrad [a,*,1], Marcel Thum [b,c,1]

[a] Max Planck Institute for Tax Law and Public Finance, Marstallplatz 1, 80539 Munich, Germany
[b] TU Dresden, Faculty of Business and Economics, 01062 Dresden, Germany
[c] ifo Dresden, Einsteinstrasse 3, 01069 Dresden, Germany

ARTICLE INFO

JEL classification:
Q34, Q35, D74, H12, H56, K33

Keywords:
Sanction
Fossil energy resources
Export embargo
Insecure property rights
International financial safe-havens

ABSTRACT

Unlike produced commodities, the extraction and sale of fossil energy resources such as oil or natural gas is an "asset swap": assets stored in the ground are converted into financial assets. The value of assets in the ground is reduced by the amount taken out and sold. This is important for assessing the coercive power of the threat of implementing an export embargo. Even if the country affected by the embargo is ruled by an autocratic kleptocrat, who appropriates all the revenues from resource sales, the sanctioning effect is close to zero in a functioning financial market environment. However, if the autocrat considers her future government power to be at risk and, at the same time, can bunker the extraction proceeds in a financial safe-haven, then the embargo leads to expected wealth losses for the autocrat. The expected wealth losses increase in the difference between the likelihood of retaining power and the wealth security of the financial assets in a safe haven. We also analyze variants of the model such as an oligopolistic resource market, where the non-sanctioned resource exporters benefit at the expense of the sanctioned country.

1. Introduction

In the Russia–Ukraine conflict, international sanctions against the Russian Federation were adopted by a large coalition of states. The menu of these sanctions is rich and diversified (for a list of sanctions see Nolsoe and Pop (2022)). Of particular importance and especially controversial were the decisions to cut off exports and to limit the trade in two major fossil energy resources: oil and natural gas. Huge sales revenues from these commodities for the Russian state budget (Dreger et al., 2016; Tuzova and Qayum, 2016) and the significant short-term dependence of various states from Russian gas and oil deposits motivate our analysis of export sanctions on fossil energy resources. The results are fairly general and also apply to other contexts where export sanctions on fossil energy resources are used. The mechanisms, which we unveil, are relevant for all fossil energy resources in the long run. In the short and medium term, however, the existing transport infrastructure determines the supply relationships in the gas market. Compared to the oil market it is much more difficult in the gas market to adjust quantities delivered or redirect extracted resources. Hence, the immediate applicability and policy conclusions of our model are for the oil market.

Natural energy resources are distinct from ordinary commodities like automobiles, steel, or microprocessors. Earnings from the production of ordinary commodities today do not affect earnings from the production of these goods in the next few years. In contrast, the markets for fossil energy resources follow the Hotelling (1931) logic of markets for depletable natural resources.[2] The overall stock is given and stored in the ground, waiting there for millions of years to be extracted and used for production processes or for consumption. The resource price also includes remuneration for capital and labor, as far as these are expended to extract the resource or transport it to demanders. For the most part, however, the proceeds of sales revenues consist of a natural resource scarcity rent.

A resource exporting country performs an "asset swap": assets stored in the ground in the form of oil are exchanged on the markets for hard currency or other financial assets, i.e., transformed into another form of wealth. If a barrel of oil is taken from the ground and sold on international markets, the resource country's stock of oil is reduced by

* Corresponding author at: Max Planck Institute for Tax Law and Public Finance, Marstallplatz 1, 80539 Munich, Germany.
E-mail address: kai.konrad@tax.mpg.de (K.A. Konrad).

[1] Contributed equally to all parts of this research.

[2] The empirical relevance of the Hotelling paradigm for oil and gas is the subject of a broad literature that finds explanations for why the empirical price path of these resources deviates from the simplest version of Hotelling logic via the inclusion of extraction costs, technological progress, geological constraints on extraction, among other factors. See, for example, Slade (1982), Venables (2014), Okullo et al. (2015), Anderson et al. (2018), and da Cunha and Missemer (2020).

https://doi.org/10.1016/j.eneco.2022.106441
Received 19 April 2022; Received in revised form 11 November 2022; Accepted 24 November 2022
Available online 29 November 2022

that barrel. Thus, apart from extraction and transaction costs, the value of the resource country's oil stock decreases by precisely the amount of the sale proceeds. An analogy might illustrate the point: The Russian Federation owns a considerable deposit of gold. The Russian state is not poorer by being prevented from selling off these gold reserves: it just has fewer financial assets, but more gold remains in the vaults in return. As far as solvability is concerned, this deposit can continue to function as collateral. By this logic, temporary export prohibitions imposed on one single exporter do not cause the same economic effects as temporary export bans for produced commodities: the losses in value-added incurred from an oil export ban are lower in proportion to the sales proceeds than for other goods that can be multiplied at will. The lion's share of the sales revenue does not make the country poorer or more prosperous. This relationship is vital in determining the cost to a country facing export sanctions.

Several effects operate on top of this fundamental logic. First, an unanticipated export embargo might cause short-run frictions for exporters and consumer countries: expensive, high-maintenance infrastructure for transportation stands idle. Liquidity costs are incurred when the government budget does not have the optimal portfolio structure in the short term. Costly fiscal liquidity shortages can occur. But in a world with fully and rationally forward-looking financial actors, such effects should not affect a country's solvability. We will abstract from such liquidity effects in the formal analysis of sanction effects.

Second, trade diversion to uninvolved third countries can render trade embargoes ineffective more generally, e.g., selling Russian oil to India instead of Europe. This is true whether the embargo relates to ordinary manufactured goods or exhaustible natural resources. To analyze the difference created by the natural exhaustibility of traded goods, we abstract from such diversion. Therefore, we assume that all consumer countries participate in the embargo and focus on the intertemporal shift in extraction caused by sanctions.

Third, one of the crucial features is the relationship between the sanctioned country and its current government. A current government might not represent the well-understood long-run interests of the people of the state as a benevolent administrator but rather appropriate personal rents in an oligarchic, kleptocratic, or dictatorial manner. The government in office can appropriate the financial benefits only if and as long as it is in the levers of power. As discussed theoretically by Long (1975) and Konrad et al. (1994), this changes the intertemporal calculus for the country as an oil supplier. Present revenues from the sales of oil can be appropriated immediately. Future revenues can only be appropriated if there is no fundamental change in government. This consideration sheds a different light on the coercive effect of oil export sanctions. A recent discussion of such effects is in Merrill and Orlando (2020), who also provide empirical evidence for the role of political instability for the desire to speed up extraction. Institutional conditions determine the intertemporal arbitrage opportunities and the objective functions of autocrats in politically unstable regimes. This aspect is at the center of our analysis.

Key results of the analysis are: In a situation of ideal oil markets with perfect competition, the temporary loss of market access for an oil exporting country imposes exactly no cost to none of the countries involved. Throughout the paper, we identify effectiveness with the damage inflicted upon the embargoed country. Most of political science literature terms sanctions as effective when they lead to a regime change (Felbermayr et al., 2021). Of course, if a sanction does not create damages to the embargoed country, it will hardly foster a regime change. Export restrictions force the embargoed exporter to shift the sale of oil into the future. In perfect markets, the oil owner is fully compensated by the price increase of the deposit over time. Payoffs of other deposit owners and energy consumer countries are also unaffected.

If the governments of resource rich countries have insecure property rights, the export embargo is cost neutral for the consumer countries and other exporting countries, but whether the embargoed government suffers from the embargo depends on the insecurity difference that exists between the probability of the autocrat of staying in office, and the probability of keeping assets shifted abroad in case the autocrat loses office.

The results are also modified if supply in the resource market is an oligopoly. The direct effect of the sanction is a shift of resource extraction of the sanctioned country into the future. In an oligopoly, the other suppliers do speed up extraction, but their reaction does not completely compensate for this delayed supply. Hence, prices are higher in the present and lower in the future, the sanction benefits these other suppliers, harms the sanctioned country and harms also the demand side of the market.

Quite a substantial literature addresses the objectives and the effectiveness of sanctions, including sanctions of different types. A seminal contribution is a theoretical analysis by Tsebelis (1990). Subsequent contributions have shown that the success of sanctions will depend, among others, on the costs of the sanctioning country, the damage to the sanctioned country, and the patience of the two parties involved (Eaton and Engers, 1992, 1999). The most recent literature also looks at the impact on third-party countries (Kwon et al., 2022) and at extraterritorial sanctions, where the sanctioning country extends its policies to trade of third countries (Janeba, 2022). The question of effectiveness has prompted a large number of empirical studies of different types of sanctions (see, e.g., Tostensen and Bull (2002)). A number of studies address the question of how sanctions affect the economy of a sanctioned country and whether they are more likely to strengthen an existing sense of "we" or lead to political resistance to one's government; see Alexseev and Hale (2020) in the Russia/Ukraine context and Farzanegan and Parvari (2014) for the sanctions on Iran. The effectiveness of sanctions after the Russian military intervention in Ukraine in 2014 has also been widely echoed in the literature (see, e.g., Andermo and Kragh (2021)). Scazzieri's (2017) analysis addresses whether the coercion exerted by sanctions following the annexation of Crimea or following the separatist events in the Donbas and Lugansk regions were sufficiently large. He also discusses Europe's willingness to strictly enforce the sanctions. From a political-economy perspective, one could argue that many sanctions are merely imposed to serve the interests of pressure groups within the sanctioning country (Kaempfer and Lowenberg, 1988). Recent surveys from several perspectives and disciplines are Early and Cilizoglu (2020), Felbermayr et al. (2021), Özdamar and Shahin (2021), and Peksen (2019). Even though the literature has analyzed many different types of sanctions (e.g., export vs. import embargoes, bi-vs. multilateral sanctions), the specific properties of natural resources, which often play an essential role for the sanctioned states, are hardly ever mentioned. Our work contributes to a better understanding of an embargo on natural resources in terms of its economic effects.

We proceed as follows. In Section 2, we use an intertemporal equilibrium model of exhaustible natural energy resources to illustrate that temporary export embargoes are completely ineffective in an otherwise frictionless world for the embargoed country as well as for other exporting countries and consumer countries. We then analyze in Section 3 the role of insecure property rights of an autocratic government in the embargoed country. We show that the embargo can be effective in this context. To be effective requires insecure property rights of the autocrat ruler, plus the ability of the ruler to stash the financial resources gained from the sale of oil and gas in a safe haven that remains available to her even after a loss of power. In Section 4, we replace perfect competition in the oil market by an oligopolistic setting. Section 5 discusses several relevant modifications of assumptions of the base model and how they affect the results, and Section 6 concludes.

2. A frictionless oil market

We consider a model with two periods, $t = 1, 2$, and three distinct economic players, or groups of players. These are denoted by

A (autocrat), C (consumer) and W (rest of exporter world). We start with an analysis of market equilibrium in a frictionless world with competitive markets and price-taking behavior. Then we consider an oil export embargo in this otherwise frictionless world to determine the sanctioning effect and possible collateral damage for other countries.

The autocrat A governs an oil-producing country in period 1. The country has a stock of oil equal to s_A, and the key decision variable of the autocrat is how much oil to sell in the market in period 1. This quantity is $x_A \in [0, s_A]$. The remaining stock $s_A - x_A$ is left for period 2, and as oil has no further economic use or value at the end of period 2, the sales of x_A implicitly determine the sales of oil in period 2 and make them equal to $y_A = s_A - x_A$.[3] Oil is sold on perfectly competitive markets in both periods, and p_1 and p_2 are its market prices in periods 1 and 2. How these are determined will be described later. Accordingly, current values of oil revenue for country A in the two periods are $p_1 \cdot x_A$ and $p_2 \cdot y_A$. The analysis could, at some notational and complexity cost, be adjusted to account for extraction cost or a consumption tax on oil.

The autocrat possesses an intertemporal utility function that accounts for the sales revenues. In the simplest format, with frictionless capital markets (e.g., a safe way to store wealth, as in former times in the form of a Swiss bank account), this utility is perfectly mapped by the present value of the sales revenues appropriated:

$$V(p_1, p_2) = p_1 \cdot x_A + \frac{1}{1+r} \cdot p_2 \cdot y_A,$$

where $(1+r)$ is the market return on a safe asset invested in period 1. If the autocrat has no safe asset, in which she can invest the amount of revenue for keeping it for the next period, this yields interesting insights and will be discussed in Section 3.

The group W may be thought of as a set of many countries, who all behave as price takers, or as a 'representative' price-taking rest-of-the-world resource country, which also have/has oil deposits and can sell them in the market in periods 1 and 2. The aggregate quantity supplied by these countries is x_W in period 1 and $y_W = s_W - x_W$ in period 2, where s_W is the aggregate stock of reserves in these countries constituting the set W at the beginning of period 1. These countries take p_1, p_2 and $(1+r)$ as given and they sell their full oil stocks to maximize the present value of sales revenues. The total stock of global oil reserves at the beginning of period 1 is denoted by $s = s_A + s_W$.

Finally, group C is the group of oil consumer countries. This group has demand in the two periods $t = 1$ and $t = 2$. The aggregate demands in the periods are described by inverse demand functions

$$p_1(X) = \left(\frac{\alpha_1}{X}\right)^{\left(\frac{1}{\epsilon}\right)} \text{ and } p_2(Y) = \left(\frac{\alpha_2}{Y}\right)^{\left(\frac{1}{\epsilon}\right)}, \quad (1)$$

where X is total demand in period 1 and Y is total demand in period 2. $\alpha_i > 0$ are shift parameters to allow for heterogeneity of demand across the two periods. The parameter ϵ denotes the absolute elasticity of demand; we assume that demand is elastic: $\epsilon > 1$. The use of constant-elasticity demand functions is common and a convenient benchmark case (see, for instance, Konrad and Lommerud (2021)), not least because perfect competition and monopoly power of resource ownership lead to identical allocations in this case (Stiglitz, 1976). Elastic demand is not essential for our main argument; the assumption just ensures that consumer surplus will be finite.

We follow here the convention of many formal analyses, such as those widely used in strategic foreign trade theory (see the survey by Brander (1995)), and analytically separate the producer countries from the group of import/consumer countries for the export good. Not much would be gained in terms of analytical insights if we were to make all countries simultaneously both oil-rich countries and oil-consuming countries. Note that, for given prices p_1 and p_2 these demand functions provide us a measure of consumer surplus from oil use. The countries, in the aggregate, purchase quantity $X^D(p_1) = \alpha_1/p_1{}^{\epsilon}$ in period 1, and $Y^D(p_2) = \alpha_2/p_2{}^{\epsilon}$ in period 2. Using the rate of interest r for discounting, the present value of aggregate consumer surplus is

$$CS_C = \int_0^X \left(\left(\frac{\alpha_1}{z}\right)^{\left(\frac{1}{\epsilon}\right)} - p_1\right) dz + \frac{1}{1+r}\int_0^Y \left(\left(\frac{\alpha_2}{z}\right)^{\left(\frac{1}{\epsilon}\right)} - p_2\right) dz. \quad (2)$$

While we focus on the penal effect of export sanctions on A, we state this welfare measure for completeness.

Equilibrium without embargo. In the absence of sanctions, the following holds:

Proposition 1. *The Walrasian equilibrium of the oil market is characterized by the pair of prices (p_1, p_2) with*

$$p_1 = \frac{1}{1+r}\left(\frac{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}{s}\right)^{\frac{1}{\epsilon}} \text{ and } p_2 = \left(\frac{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}{s}\right)^{\frac{1}{\epsilon}}. \quad (3)$$

These prices are market-clearing and lead to aggregate demands and supplies

$$X^D = X^S = x_A(p_1,p_2) + x_W(p_1,p_2) = s \cdot \frac{\alpha_1 \cdot (1+r)^{\epsilon}}{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2} \quad (4)$$
$$\text{and } Y^D = Y^S = y_A(p_1,p_2) + y_W(p_1,p_2) = s \cdot \frac{\alpha_2}{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}.$$

Proof. The price vector (p_1, p_2) characterizes the Walrasian equilibrium if, for this pair of prices, demand equals supply in both periods. Demands for these prices are given by the demand functions (1). These demand functions $X^D(p_1,p_2)$ and $Y^D(p_1,p_2)$ are monotonically decreasing in the respective own price. Turning to the supply side, applying the Hotelling (1931) logic, supply of resource owner $I \in \{A\} \cup W$ is a correspondence

$$(x_I, y_I) = \begin{cases} (s_I, 0) & \text{if } p_1(1+r) > p_2 \\ (x_I, y_I) \in \Sigma_I(s_I) & \text{if } p_1(1+r) = p_2 \\ (0, s_I) & \text{if } p_1(1+r) > p_2 \end{cases}$$

where $\Sigma_I(s_I)$ is the set of all pairs $(x_I, y_I) \in [0, s_I] \times [0, s_I]$ with $x_I + y_I = s_I$. These optimal supplies add up to aggregate supply $(X^S, Y^S) \in [0, s] \times [0, s]$ with $X^S + Y^S = s$. At the candidate equilibrium prices, demands are

$$X^D(p_1,p_2) = \frac{\alpha_1}{p_1{}^{\epsilon}} = s \cdot \frac{\alpha_1 \cdot (1+r)^{\epsilon}}{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}$$

and

$$Y^D(p_1,p_2) = \frac{\alpha_2}{p_2{}^{\epsilon}} = s \cdot \frac{\alpha_2}{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}.$$

These demand quantities add up to $X^D(p_1,p_2) + Y^D(p_1,p_2) = s$. Now, for the candidate equilibrium prices, the Hotelling rule $p_1(1+r) = p_2$ holds, such that any supply vector $(X^S, Y^S) \in [0, s] \times [0, s]$ with $X^S + Y^S = s$ is the aggregate of optimal supplies, and this set includes $X^S = X^D$ and $Y^S = Y^D$.

Uniqueness can be proven by contradiction, showing that there is no market clearing pair $(\hat{p}_1, \hat{p}_2)$ for which $\hat{p}_1 \geq p_1$ and $\hat{p}_2 \geq p_2$ with one of these inequalities holding strictly, and no market clearing pair $(\hat{p}_1, \hat{p}_2)$ for which $\hat{p}_1 \leq p_1$ and $\hat{p}_2 \leq p_2$ with one of these inequalities holding strictly, and that any combination $(\hat{p}_1, \hat{p}_2)$ with $\hat{p}_1 < p_1$ and $\hat{p}_2 > p_2$ or with $\hat{p}_1 > p_1$ and $\hat{p}_2 < p_2$ leads to a corner solution and violates $x_A(p_1,p_2) + x_W(p_1,p_2) = X^D(p_1,p_2)$. ■

We can also denote the values of further macro parameters of this equilibrium. Oil profits for A and W are

$$\pi_A = \frac{s_A}{1+r}\left(\frac{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}{s}\right)^{\frac{1}{\epsilon}} \text{ and}$$

[3] The two periods could be partitioned into a larger number of periods or a time continuum. However, two periods are sufficient to analyze an intertemporal choice with sanctions. Moreover, period 2 need not have the same length as period 1 and can well be understood as being very long, collapsing all future periods after period 1 into one, and encompassing the end of any time horizon.

$$\pi_W = \frac{s_W}{1+r}\left(\frac{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}{s}\right)^{\frac{1}{\epsilon}}.$$

Consumer surplus is

$$CS_C = \int_0^X \left(\frac{\alpha_1}{z}\right)^{\frac{1}{\epsilon}} dz + \frac{1}{1+r}\int_0^Y \left(\frac{\alpha_2}{z}\right)^{\frac{1}{\epsilon}} dz - \frac{s}{1+r}\left(\frac{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}{s}\right)^{\frac{1}{\epsilon}},$$

which can also be written as

$$CS_C = \frac{1}{\epsilon - 1}\frac{s}{1+r}\left(\frac{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}{s}\right)^{\frac{1}{\epsilon}}.$$

Equilibrium with embargo. An export embargo in period 1 for country A is formally represented by the constraint $(x_A, y_A) \equiv (0, s_A)$. Note that the condition $p_1(1+r) = p_2$ still is the condition that makes all $I \in W$ indifferent about how to allocate s_I to x_I and y_I. This constraint implies that, the aggregate supply correspondence at the equilibrium candidate price vector (p_1, p_2) becomes $(X^S, Y^S) \in [0, s - s_A] \times [s_A, s]$ with $X^S + Y^S = s$. Hence, the equilibrium supply from Proposition 1, $(X^S, Y^S) = (X^S(p_1, p_2), Y^S(p_1, p_2))$ is part of the equilibrium aggregated supply correspondence if $s - s_A = s_W \geq X^S(p_1, p_2) = s \cdot \frac{\alpha_1 \cdot (1+r)^{\epsilon}}{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}$. Summarizing this, we note:

Proposition 2. *If a sanction $x_A \equiv 0$ is imposed, the Walrasian equilibrium (p_1, p_2) in Proposition 1 remains the Walrasian equilibrium under such a sanction if*

$$s_W > s \cdot \frac{\alpha_1 \cdot (1+r)^{\epsilon}}{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}. \tag{5}$$

The sanction reduces A's supply x_A to zero by definition. If the stock of oil of countries W is sufficiently large (larger than the full equilibrium demand X in (4) in the Walrasian equilibrium in period 1), then these countries can provide the equilibrium supply in period 1 on their own, and they are indifferent whether they should do this, due to the Hotelling condition. This intertemporal supply adjustment has no implications for prices, aggregate quantities, payoffs, and rents — for none of the countries. Even the country facing the export embargo is entirely indifferent to the embargo, as it is indifferent whether to extract and sell now or later.

3. Insecure property rights

Let us now add some important ingredients into the model: the government in A suffers from two types of insecure property rights, whereas the group W of countries stands for oil supply that does not suffer from such problems.

Equilibrium without embargo. Let all assumptions about the group W of non-sanctioned exporters remain unchanged: the total stock of oil possessed by W is s_W and can be sold in arbitrary non-negative quantities x_W and $y_W = s_W - x_W$ in the two periods. The individual decisions of countries in group W maximize present value of revenues

$$p_1 \cdot x_W + \frac{1}{1+r} \cdot p_2 \cdot (s_W - x_W)$$

by the choice of $x_W \in [0, s_W]$ and are, for this purpose, price takers.

The group C consists of a non-atomistic group of countries with an aggregate import demand for oil for each period described by (1) and welfare of this group is expressed by (2).

Country A has oil deposits of s_A at the beginning of period 1 and is governed by an autocrat in that period. This autocrat chooses $x_A \in [0, s_A]$. This decision implicitly determines the country's supply $y_A = s_A - x_A$ in period 2. The autocrat can fully appropriate the sales revenues of period 1. Whether or not the autocrat remains in power in period 2 is uncertain. The autocrat's probability to remain in power is $\delta \in [0,1]$.[4] This probability is exogenous in the context here. Hence, the autocrat appropriates the oil revenues in period 2 with this probability. With the remaining probability, the autocrat loses power and is replaced by a different government. The assumptions about appropriation and insecure power can be relaxed, for instance, giving the autocrat only an exogenous and constant share in the sales revenues for each period in which she is in power. A more elaborate analysis might also endogenize both dimensions along the line of thoughts in Edwards and Keen (1996). Whoever rules in period 2, sells the remaining stock $y_A = s_A - x_A$ at the prevailing price p_2.

Intertemporal consumption choices of the autocrat become of potential relevance. The autocrat considered here consumes only in period 2 and is risk-neutral. So the autocrat likes to invest the sales returns from period 1 in the financial market. The ongoing interest rate in the financial market is $(1+r)$. As pointed out by Konrad et al. (1994), investment in the financial market might not be a safe way to preserve revenue appropriated in period 1 for consumption in period 2. The intertemporal shift might work well without a regime change in country A. However, in case of a regime change, the autocrat might also lose the financial assets, even if stored in a safe haven country or in a Swiss bank account. We define $1 - \lambda$ as the probability for such a confiscation/loss of assets. We assume $\lambda \geq \delta$. The autocrat might lose power, but keep her safe-haven accounts. If these accounts are also confiscated with the loss of power, then $\lambda = \delta$. If the autocrat can keep access to her assets with a certain probability, then $\lambda > \delta$.[5] Her security issue with respect to financial assets is illustrated by the 2022 leaks on asset management behavior by Credit Suisse: on the one hand the leaks and the stories written about it suggest that autocrats and convicted criminals are able to store wealth in financial havens but on the other hand the case of the leak itself suggests that these assets are not perfectly safe for them there, either.[6] The present value of expected payoffs to the autocrat as a function of x_A can be written as

$$\lambda \cdot p_1 \cdot x_A + \delta \frac{1}{1+r} \cdot p_2 \cdot (s_A - x_A).$$

Proposition 3. *Let $1 \geq \lambda > \delta > 0$ and let (5) hold. The Walrasian equilibrium of the oil market is characterized by the pair of prices (3) such that $(x_A, y_A) = (s_A, 0)$, but aggregate demand and supply is (4).*

Proof. The proof follows similar lines as for Proposition 1. The price vector (p_1, p_2) characterizes the Walrasian equilibrium if, for this pair of prices, aggregate demand equals aggregate supply in both periods. Demands for these prices are given by the demand functions (1). These demand functions $X^D(p_1, p_2)$ and $Y^D(p_1, p_2)$ are monotonically decreasing in the respective own price. Turning to the supply side, applying the Hotelling (1931) logic, supply of oil owners W is a correspondence

$$(x_W, y_W) = \begin{cases} (s_W, 0) & \text{if} \quad p_1(1+r) > p_2 \\ (x_W, y_W) \in \Sigma_I(s_W) & \text{if} \quad p_1(1+r) = p_2 \\ (0, s_W) & \text{if} \quad p_1(1+r) < p_2 \end{cases}$$

[4] To illustrate, data from March 24, 2022 suggests that Putin will be in power by the end of the year with odds 76:24, which implies a dramatic discount rate. For betting odds, see https://www.predictit.org/markets/detail/7760/Will-Vladimir-Putin-remain-president-of-Russia-through-2022m accessed on March 24, 2022.

[5] The opposite case $\lambda < \delta$ is less interesting for the question of the effectiveness of sanctions. Here, the risk of losing the Swiss bank account is larger than the risk of a regime change. There is no incentive to swap oil for financial assets. The oil would remain in the ground and sanctions were ineffective.

[6] See, e.g., Jesse Drucker and Ben Hubbard Feb. 20, 2022, "Vast Leak Exposes How Credit Suisse Served Strongmen and Spies", New York Times or David Pegg, Kalyeena Makortoff, Martin Chulov, Paul Lewis and Luke Harding, Sun 20 Feb 2022, "Revealed: Credit Suisse leak unmasks criminals, fraudsters and corrupt politicians" The Guardian, https://www.theguardian.com/news/2022/feb/20/credit-suisse-secrets-leak-unmasks-criminals-fraudsters-corrupt-politicians.

where $\Sigma_I(s_W)$ is the set of all pairs $(x_W, y_W) \in [0, s_W] \times [0, s_W]$ with $x_W + y_W = s_W$. Supply by A is a correspondence

$$(x_A, y_A) = \begin{cases} (s_A, 0) & \text{if} \quad \lambda p_1(1+r) > \delta p_2 \\ (x_W, y_W) \in \Sigma_1(s_W) & \text{if} \quad \lambda p_1(1+r) = \delta p_2 \\ (0, s_W) & \text{if} \quad \lambda p_1(1+r) < \delta p_2 \end{cases}$$

where $\Sigma_1(s_A)$ is the set of all pairs $(x_A, y_A) \in [0, s_A] \times [0, s_A]$ with $x_A + y_A = s_A$. Optimal supplies add to aggregate supply $(X^S, Y^S) \in [0, s] \times [0, s]$ with $X^S + Y^S = s$. At the candidate equilibrium price vector, demands are

$$X^D(p_1, p_2) = \frac{\alpha_1}{p_1{}^\epsilon} = s \cdot \frac{\alpha_1 \cdot (1+r)^\epsilon}{\alpha_1 \cdot (1+r)^\epsilon + \alpha_2} \tag{6}$$

and

$$Y^D(p_1, p_2) = \frac{\alpha_2}{p_2{}^\epsilon} = s \cdot \frac{\alpha_2}{\alpha_1 \cdot (1+r)^\epsilon + \alpha_2}. \tag{7}$$

The demand quantities add to $X^D(p_1, p_2) + Y^D(p_1, p_2) = s$. With the candidate equilibrium prices $p_1(1+r) = p_2$, A strictly prefers to sell all oil stock in period 1, whereas the oil deposit owners in W are all indifferent about when to sell. Accordingly, any supply vector $(X^S, Y^S) \in [s_A, s] \times [0, s - s_A]$ with $X^S + Y^S = s$ is an aggregate supply that is optimal given the candidate price vector. If (5) holds, then this set includes $X^S = X^D$ and $Y^S = Y^D$. Uniqueness of (p_1, p_2) can again be proven by contradiction and this proof is omitted here. ■

Intuitively, the autocrat faces the problem of a possible loss of office. Most likely, this goes along with a loss of access to the revenue from oil reserves of the country. The autocrat is also bothered by the fact that the oil revenue she appropriated in period 1 and shifted to a safe haven might be less than entirely safe in case of office loss. International banks are supposed not to offer bank accounts and safe holdings of assets for kleptocrat politicians, particularly once they lose power. Hence, if their financial holdings are not safe but less threatened than the potential gains from appropriating future returns from oil, then an autocrat/kleptocrat is eager to exploit the oil deposits of her country more quickly. She needs a higher implicit return $\frac{\lambda}{\delta}(1+r)$ than regular countries to keep oil in the ground in period 1.

Equilibrium with an embargo. Consider now a ban on oil exports for country A in period 1: $x_A \equiv 0$. The following holds:

Proposition 4. *The Walrasian equilibrium of the oil market is characterized by a pair of prices as in (3) such that $(x_A, y_A) = (0, s_A)$, and aggregate demand and supply is (4) if*

$$s_W > s \cdot \frac{\alpha_1 \cdot (1+r)^\epsilon}{\alpha_1 \cdot (1+r)^\epsilon + \alpha_2}. \tag{8}$$

Proof. An export embargo in period 1 for country A is formally represented by the constraint $(x_A, y_A) \equiv (0, s_A)$. Note that the condition $p_1(1+r) = p_2$ still holds, as the candidate equilibrium price vector is the same as in Proposition 3. This condition makes all countries in W indifferent about how much of their oil to extract and sell in period 1. Accordingly, any $(x_W, y_W) \in [0, s_W] \times [0, s_W]$ with $x_W + y_W = s_W$ is an optimal supply vector given the candidate equilibrium prices. The government in country A prefers to extract and sell in period 1, the embargo does not allow this, however, and requires $(x_A, y_A) = (0, s_A)$. This constraint requires that the aggregate supply correspondence at the equilibrium candidate price vector (p_1, p_2) becomes $(X^S, Y^S) \in [0, s - s_A] \times [0, s]$ with $X^S + Y^S = s$. This implies that $(X^S, Y^S) = (X^D, Y^D)$ is an element in the set of optimal supply vectors if

$$X^D = s \cdot \frac{\alpha_1 \cdot (1+r)^\epsilon}{\alpha_1 \cdot (1+r)^\epsilon + \alpha_2} < s - s_A = s_W.$$

This holds given (8). ■

Note that (8) is similar in spirit to (5), requiring that the overall deposits of the oil owners other than A are sufficient to cover the period-1 demand. We can also denote and summarize the values of additional macro parameters of this equilibrium. The interesting aspect emerges if we compare equilibrium payoffs with and without sanctions. Price path and aggregate demands do not change; hence, the welfare of the country C remains unaffected. The same applies for the payoff of the group W. They change their supplies in periods 1 and 2, but overall their payoff remains equal to

$$\pi_W = \frac{s_W}{1+r} \left(\frac{\alpha_1 \cdot (1+r)^\epsilon + \alpha_2}{s} \right)^{\frac{1}{\epsilon}}.$$

Finally, the autocrat in country A is forced to extract and sell at a different time. As the autocrat was not indifferent in the no-sanctions regime about when to extract and sell, this harms the autocrat. The payoff loss can straightforwardly be calculated and is

$$L_A = \frac{s_A}{s} \left(\delta p_2 \frac{1}{1+r} - \lambda p_1 \right) = \frac{s_A}{s} (\delta - \lambda) p_1.$$

This term is negative, as $\delta < \lambda$. For prevailing equilibrium prices the autocrat has a strict preference for early extraction and sales. The sanction imposes a burden on her and reduces her payoff by L_A.

It is important to note that the punishment effect of an oil export embargo is more significant the larger is the difference between δ and λ. The coercive power of the oil export embargo is thus more significant when the autocrat feels higher political insecurity and sees his rule endangered, and more significant when the financial resources he has brought to a financial safe haven is well and safely stored there for him beyond the end of his rule. With insecure property rights for her financial assets, the threat of a freeze and potential expropriation of financial assets per se reduces the expected wealth of the autocrat. However, when used in conjunction with export embargoes, the freeze of financial assets weakens the harm inflicted by the embargo.[7]

4. Market power

Natural energy resource markets have a number of large suppliers, and the assumption of perfect price competition therefore does not do full justice to the complexity of these markets. A small number of countries in the Middle East, Russia and the US cover more than 50 percent of all oil exports in the world (BP, 2022), many other countries contribute small amounts to overall supply (home and export). How does market structure modify the effectiveness of sanctions?

As outlined by Stiglitz (1976), perfect competition among oil producers is not essential for the intertemporal Hotelling rule. For constant-elasticity demand and in the absence of resource extraction costs, the equilibrium values for perfect competition and monopoly even coincide. Salant (1976) analyses a 'dominant extractor model'. This player is either a player with a sizeable stock, or a cartel of a group of extractor countries in a market with price-taking other countries. He finds that price-taking extractors tend to extract earlier. Their marginal revenue in each period is equal to the present value of the price. As long as their stocks are not exhausted, the equilibrium price increases with the interest rate. The dominant extractor has a lower marginal revenue, because an increase in own supply decreases the price of the amount this player supplies. This effect tends to delay extraction. Whether or not, and by how much, a sanction harms the sanctioned country would then depend on whether the country is more like a price taker or more like a country with sizeable market share, and also on the size of the

[7] In 2012, the Council of the European Union Council announced an embargo on Iranian oil exports and a freeze of assets held by the Central Bank of Iran to force the Iranian government to give up on the nuclear program (European Union, 2012). The freeze itself reduces Iran's disposable wealth but reduced Iran's incentive for oil exports thus weakening the impact of the concurrent export sanction.

total resource stock and its distribution among countries. A survey that illustrates the rich set of market structures of an exhaustible natural resource is by Lambertini (2018).

To illustrate some of the underlying forces by which market power can affect the impact of sanctions we study a duopoly market. Let W be a single country (or a cartel), such that the oil market is a duopoly with two sellers: A and W. To simplify the analytical solution, assume furthermore symmetry: each country possesses half of the global oil reserves ($s_W = s_A = \frac{s}{2}$). Country W chooses $x_W \in [0, s_W]$ that maximizes present value of W's revenues:

$$\pi_W = p_1(X) \cdot x_W + \frac{1}{1+r} \cdot p_2(Y) \cdot (s_W - x_W), \tag{9}$$

where $X \equiv x_A + x_W$ and $Y \equiv y_A + y_W = s_A - x_A + s_W - x_W$. Similarly, the government of country A chooses $x_A \in [0, s_A]$ that maximizes present value of the revenues of the ruling government in A:

$$\pi_A = p_1(X) \cdot x_A + \frac{1}{1+r} \cdot p_2(Y) \cdot (s_A - x_A).$$

In the Nash equilibrium, the two choices x_A and x_W are mutually optimal replies.

We first look at the scenario without sanctions. Consider the first-order conditions of the two countries for an equilibrium, in which W offers positive quantities in both periods. For isoelastic demand, the first-order conditions for an interior payoff maximum for country W transform into

$$(1+r) \cdot p_1(x_W + x_A) \cdot \left[1 - \frac{1}{\epsilon} \frac{x_W}{x_W + x_A}\right] = p_2(y_W + y_A) \cdot \left[1 - \frac{1}{\epsilon} \frac{\frac{s}{2} - x_W}{s - x_W - x_A}\right]. \tag{10}$$

Given that the total resource stock $s_A + s_W$ is depleted and sold in the equilibrium, this determines the values of p_1 and p_2. In the symmetric equilibrium, the market shares of the two countries are the same and constant over time. The first-order condition for a payoff maximum simplifies to

$$(1+r) \cdot p_1(x_W + x_A) = p_2(y_W + y_A).$$

This is just the Hotelling rule. In the symmetric equilibrium, the duopoly generates the same outcome as perfect competition. We denote the equilibrium values in the duopoly without sanctions as (p_1^o, p_2^o, X^o, Y^o).

With sanctions, the first-period sales of country A are set to zero ($x_A = 0$). Country W maximizes the present value of profits (9). The first-order condition can be written as:

$$(1+r) \cdot p_1(x_W) \cdot \left[1 - \frac{1}{\epsilon}\right] = p_2(y_W + y_A) \cdot \left[1 - \frac{1}{\epsilon} \frac{\frac{s}{2} - x_W}{s - x_W}\right]. \tag{11}$$

Denote the equilibrium outcome in the sanctions scenario with (p_1^s, p_2^s, X^s, Y^s).

A comparison of the two scenarios immediately shows that sanctions are no longer neutral in an oligopolistic market. The modified Hotelling rule of Eq. (11) tells us that the sanctions increase the price in the first period ($p_1^s > p_1^o$) and lower the price in the second period ($p_2^s < p_2^o$). Correspondingly global oil sales are lower, while the sanction regime is in place ($X^s < X^o$). As the sanctioned country A is not allowed to sell its oil in the world market in period 1, it suffers a loss in present value terms. Country W gains from the sanctions. By the assumptions made, country W could completely offset the loss in sales from A and achieve the same aggregate outcome as in the symmetric equilibrium without sanctions. But this is not a profit maximizing choice. Country W finds it optimal to reduce total output in period 1 at the cost of higher output in the future. The resulting price increase in period 1 falls on all inframarginal oil sales, which all come from country W, while the disadvantage of lower oil prices in the future is shared with country A.

5. Further variants of the model and future research

Without elaborating on the technical details, we discuss some of the simplifying assumptions in our model. Where appropriate, we will refer to related academic work that has analyzed such variations in the assumptions. We also briefly highlight variations of the model that could provide avenues for future research.

Extraction costs. The introduction of extraction costs per se would not affect the analysis of sanctions qualitatively (but of course make the formulas harder to read). When marginal extraction costs are positive, the (modified) Hotelling rule requires that the resource rent – the difference between price and marginal costs of extraction – grows with the interest rate. With respect to the sanctions, the same logic applies as in our standard model. A more interesting scenario emerges with heterogeneous extraction costs. If country A is the low cost country, it should extract first and would do so in a laissez-faire market economy. Effective embargoes that force country A to extract later in time causes a damage to the sanctioned country as a low-cost producer is not fully compensated by the equilibrium price increase. The present value of resource rents is decreased by the sanction.

Consumption preferences. In the basic model, the autocrat only cares for the present value of resource rents. With complete financial markets, the autocrat can achieve any consumption pattern across the two periods by saving or borrowing. We might account for intertemporal consumption preferences with $W(C_A^1, C_A^2)$, where C_A^t stands for the autocrat's consumption in period t. The maximized utility from intertemporal consumption will be

$$V(p_1 \cdot x_A + \frac{1}{1+r} \cdot p_2 \cdot y_A).$$

and, therefore, equivalent to our simplifying approach. The higher the present value of oil revenues the higher will be this intertemporal utility. Variations in the utility function can affect the outcome, if financial markets are incomplete or if insecure property rights are introduced as in Section 3. A second variation of the autocrat's preferences could take into account risk. With risk-aversion, the probabilities for a regime change and a seizure of assets would matter beyond the pure loss of expected wealth. Without formal analysis and a specification of the risk preferences it is impossible to tell how this will affect the results.[8] A third variation of the model could draw a more complex political-economy picture. The present value of resource rents may be a good proxy for the fulfillment of many objectives that matter in the political sphere. With a larger wealth, the autocrat can spend more on her own consumption but it can also be used for buying votes or creating lucrative government jobs. However, there are also aspects that are not covered by the magnitude of the resource rents. For instance, different types of sanctions might harm groups in society differently; inflicting damage on particularly powerful groups may have other consequences than harming the broader public.

Endogeneity of regime stability. We have assumed that the probability λ that the autocrat stays in power is exogenously given. An interesting avenue for future investigations could make the probability of a regime change endogenous. See, for instance, Acosta (2018) for a model, where the expropriation risk is endogenous and depends on the oil wealth in the ground.

[8] Other sources of uncertainty such as incomplete information about the oil reserves or the risk of a extraction freeze imposed by global climate policy would affect all players equally.

6. Conclusions and policy implications

Viewing an embargo for oil and gas exports from the perspective of natural resource economics establishes some insights. If sanctions are meant as punishment or coercion and the choice of it aims at making the coercive threat bite, these insights are suggestive for when such an embargo is a more or less useful choice of sanctions.

The first insight is on an oil export embargo within a framework of functioning intertemporal financial and resource markets: banning a supplier temporarily (e.g., several years) from the market is ineffective in this benchmark model. The export embargo induces changes and market adjustments by the set of other oil exporters that completely undo the direct effects of an oil export embargo. This holds under perfect competition, where other exporters adjust their intertemporal choices and perfectly compensate for the change in the extraction path of the sanctioned country. Qualitatively similar substitution effects emerge in an oligopoly — the other country or countries at least shift their extraction activities more to the present and partially compensate for the supply shortfall. The intuition behind this result is that oil and gas are not ordinary commodities but are similar to financial assets. They can be consumed, used to store value, or sold and transformed into other financial assets. If an export embargo is imposed on a country, this prevents the country from exchanging one asset into another one but does not debase the resource stock. Foregone profits from oil sales are not really losses, as the asset remains in the ground.

An export embargo can hurt an authoritarian government in the embargoed country, even if the international market for oil reserves is perfectly fungible. This is true if this government is particularly affected by the threat of losing political power in its country. At the intertemporal equilibrium price path, this country has a clear incentive to speed up extraction. The regular rate of return in financial markets is inadequate compensation for delaying extraction. The embargo forces the government of such a country to delay extraction. What the government receives from future extraction is less valuable for the government than immediate extraction. This is because this government will lose power with some probability and will then not enjoy the fruits of future extraction.

Summarizing, the flow of foregone revenues of an oil or gas exporter turns out to be a poor and conceptually flawed indicator of the damage imposed on the embargoed country. This is because extracting crude oil and selling it is not mainly value creation but an asset swap, in which the exporting country converts the sales value of such fossil fuels deposits into financial assets. Under ideal conditions (perfect financial markets, no transaction costs, secure property rights in particular), the damage imposed on the sanctioned country is zero. We also show that a sanctioned autocrat's incomplete political office security can change the picture. Whether or not an embargo of fossil fuels hurts the autocrat then depends on whether the autocrat's political property rights in future resource extraction rents are less secure than her property rights in financial assets she stacked in international financial safe-havens. The damage is more severe if the political property rights in future resource extraction rents are weaker than those in financial assets shifted to international safe-havens. This is a relevant policy message that might stimulate the debate about export embargoing autocrat governments' natural resource exports.

CRediT authorship contribution statement

Kai A. Konrad: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing, Supervision, Project administration. **Marcel Thum:** Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing, Supervision, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

We thank Albrecht Ritschl, Ronnie Schöb, Hans-Werner Sinn and two anonymous reviewers for very helpful comments and suggestions.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Acosta, Mauricio Rodriguez, 2018. Resource management under endogenous risk of expropriation. Resour. Energy Econ. 52, 1–17.
Alexseev, Mikhail A., Hale, Henry E., 2020. Crimea come what may: Do economic sanctions backfire politically? J. Peace Res. 57 (2), 344–359.
Andermo, Erik, Kragh, Martin, 2021. Sanctions and dollar dependency in Russia: resilience, vulnerability, and financial integration. Post-Soviet Aff. 37 (3), 276–301.
Anderson, Soren T., Kellogg, Ryan, Salant, Stephen W., 2018. Hotelling under pressure. J. Polit. Econ. 126 (3), 984–1026.
BP, 2022. Statistical Review of World Energy 2022, 71th edition.
Brander, James A., 1995. Strategic trade policy. In: Handbook of International Economics, Vol. 3. pp. 1395–1455.
da Cunha, Roberto Ferreira, Missemer, Antoine, 2020. The hotelling rule in non-renewable resource economics: A reassessment. Can. J. Econ. 53 (2), 800–820.
Dreger, Christian, Kholodilin, Konstantin A., Ulbricht, Dirk, Fidrmuc, Jarko, 2016. Between the hammer and the anvil: The impact of economic sanctions and oil prices on Russia's ruble. J. Comp. Econ. 44, 295–308.
Early, Bryan R., Cilizoglu, Menevis, 2020. Economic sanctions in flux: enduring challenges, new policies, and defining the future research agenda. Int. Stud. Perspect. 21 (4), 438–477.
Eaton, Jonathan, Engers, Maxim, 1992. Sanctions. J. Polit. Econ. 100 (5), 899–928.
Eaton, Jonathan, Engers, Maxim, 1999. Sanctions: Some simple analytics. Amer. Econ. Rev. 89 (2), 409–414, Papers and Proceedings.
Edwards, Jeremy, Keen, Michael, 1996. Tax competition and leviathan. Eur. Econ. Rev. 40 (1), 113–134.
European Union, 2012. Council conclusions on Iran. In: 3142th Foreign Affairs Council Meeting, Brussels, 23 January 2012.
Farzanegan, Mohammad Reza, Parvari, Mozhgan Raeisian, 2014. Iranian-oil-free zone and international oil prices. Energy Econ. 45, 364–372.
Felbermayr, Gabriel, Clifton Morgan, T., Syropoulos, Constantinos, Yotov, Yoto V., 2021. Understanding economic sanctions: Interdisciplinary perspectives on theory and evidence. Eur. Econ. Rev. 135, 103720.
Hotelling, Harold, 1931. The economics of exhaustible resources. J. Polit. Econ. 39, 137–175.
Janeba, Eckhard, 2022. Extraterritorial Trade Sanctions: Theory and Application To the US-Iran-EU Conflict. CESifo Working Paper No. 9573.
Kaempfer, William H., Lowenberg, Anton D., 1988. The theory of international economic sanctions: A public choice approach. Amer. Econ. Rev. 78 (4), 786–793.
Konrad, Kai A., Lommerud, Kjell Erik, 2021. Effective climate policy needs non-combustion uses for hydrocarbons. Energy Policy 157, 112446.
Konrad, Kai A., Olsen, Trond E., Schöb, Ronnie, 1994. Resource extraction and the threat of possible expropriation: The role of Swiss bank accounts. J. Environ. Econ. Manag. 26 (2), 149–162.
Kwon, Ohyun, Syropoulos, Constantinos, Yotov, Yoto V., 2022. The Extraterritorial Effects of Sanctions. CESifo Working Paper No. 9578.
Lambertini, Luca, 2018. Differential oligopoly games in environmentaland resource economics. In: Corchón, Luis C., Marini, Marco A. (Eds.), Handbook of Game Theory and Industrial Organization, Volume II, Applications. pp. 338–366.
Long, Ngo Van, 1975. Resource extraction under the uncertainty about possible nationalization. J. Econom. Theory 10 (1), 42–53.
Merrill, Ryan K., Orlando, Anthony W., 2020. Oil at risk: Political violence and accelerated carbon extraction in the middle east and north africa. Energy Econ. 92, 104935.
Nolsoe, Eir, Pop, Valentina, 2022. Russia Sanctions List: What the West Imposed over the Ukraine Invasion. Financial Times, March 4 2022, accessed on March 14, 2022, https://www.ft.com/content/6f3ce193-ab7d-4449-ac1b-751d49b1aaf8).
Okullo, Samuel J., Reynès, Frédeéric., Hofkes, Marjan W., 2015. Modeling peak oil and geological constraints. Resour. Energy Econ. 40, 36–56.
Özdamar, Özgür, Shahin, Evgniia, 2021. Consequences of economic sanctions: The state of the art and paths forward. Int. Stud. Rev. 23 (4), 1646–1671.

Peksen, Dursun, 2019. When do imposed economic sanctions work? A critical review of the sanctions effectiveness literature. Def. Peace Econ. 30 (6), 635–647.
Salant, Stephen W., 1976. Exhaustible resources and industrial structure: A Nash-cournot approach to the world oil market. J. Polit. Econ. 84 (5), 1079–1094.
Scazzieri, Luigi, 2017. Europe, Russia and the Ukraine crisis: the dynamics of coercion. J. Strateg. Stud. 40 (3), 392–416.
Slade, Margaret E., 1982. Trends in natural-resource commodity prices: an analysis of the time domain. J. Environ. Econ. Manag. 9 (2), 122–137.
Stiglitz, Joseph E., 1976. Monopoly and the rate of extraction of exhaustible resources. Amer. Econ. Rev. 66 (4), 655–661.
Tostensen, Arne, Bull, Beate, 2002. Are smart sanctions feasible? World Politics 54 (3), 373–403.
Tsebelis, George, 1990. Are sanctions effective? J. Confl. Resolut. 34 (1), 3–28.
Tuzova, Yelena, Qayum, Faryal, 2016. Global oil glut and sanctions: The impact on Putin's Russia. Energy Policy 90, 140–151.
Venables, Anthony J., 2014. Depletion and development: Natural resource supply with endogenous field opening. J. Assoc. Environ. Resour. Econ. 1 (3), 313–336.