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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.

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

Keywords: war, Sanction, fossil energy resources, export embargo, depletable resources, crude oil, Natural gas, autocratic government, insecure property rights, Safety of International Financial Safe-havens

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April 19, 2022

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.

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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.[1] 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, Kholodilin, Ulbricht and Fidrmuc 2016, Tuzova and Qayum 2016) and the significant short-term dependence of various states from fossil energy resources such as imports of gas and oil from Russian deposits motivate our analysis of export sanctions on oil and gas. The results are fairly general and also apply to other contexts where export sanctions on fossil energy resources such as oil and gas are used.

Oil and natural gas 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 such as crude oil and natural gas follow the Hotelling (1931) logic of markets for depletable natural resources.[2] The overall stock of oil and gas is given and stored in the ground, waiting there for millions of years to be extracted from storage and used for production processes or for consumption. The price of natural gas and oil also includes remuneration for capital and labor, as far as these are expended to get the oil and gas out of the ground or transport it to demanders. For the most part, however, the proceeds of sales revenues consist of a natural resource scarcity rent.

An oil or gas 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 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.[3] By this logic, temporary export

[1] Targeted travel restrictions and confiscation of assets for members of Russia's ruling elite are arguably intended to put pressure on a narrowly restricted group of individuals and influence government policy decisions. Bans on the supply of spare parts and factors of production are intended to disrupt value chains in Russia and in this way hit Russia's economic strength and thus its prosperity. Freezing foreign currency reserves held abroad and isolating Russia's financial sector from the international financial infrastructure might reduce the country's ability to act economically (see for a list of sanctions Eir Nolsoe and Valentina Pop, Financial Times, March 4 2022, Russia sanctions list: What the west imposed over the Ukraine invasion, accessed on March 14, 2022, https://www.ft.com/content/6f3ce193-ab7d-4449-ac1b-751d49b1aaf8).

[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, Reynés, and Hofkes (2015), Anderson, Kellogg, and Salant (2018), and da Cunha and Missemer (2020).

[3] An analogy might illustrate the point: The Russian Federation owns a considerable deposit

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 liquidity effects in the formal analysis of sanction effects. We document the (in)effectiveness of sanctions within the framework of exhaustible resources.[4]

Second, 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, Olsen, and Schöb (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.[5]

Key results of the analysis are: In a situation of ideal oil and gas markets with perfect competition, the temporary loss of market access for an oil and gas exporting country imposes exactly no cost to none of the countries involved. Export restrictions force the embargoed exporter to shift the sale of oil and gas into the future. In perfect markets, the oil and gas owner is fully compensated by the price increase of the deposit over time. Payoffs of other oil and gas owners and oil consumer countries are also unaffected. If the governments of oil and gas-rich countries have insecure property rights, the oil export embargo is costly for them but neutral for the consumer countries and other oil-exporting countries.

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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.

[4] 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, Morgan, Syropoulos and Yotov, 2021). Of course, if a sanction does not create damages to the embargoed country, it will hardly foster a regime change.

[5] 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.

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 (2019) 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 oil and gas 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 apply these considerations to the Ukraine conflict. Piecemeal evidence suggests that insecure property rights may be significant for the current rulers in the Russian Federation. We show that the embargo can be effective in this context, provided that the rulers can shift financial resources to safe-havens. The freeze of foreign assets often observed illustrates that these assets might also be lost if the current rulers lose power, in which case the export embargo loses its bite.

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.[6] 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 $y_A = s_A - x_A$.[7] 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 $x_A p_1$ and $y_A p_2$.[8]

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:

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

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.[9]

[6] For the analysis and convenience in writing, we lump crude oil and natural gas into 'oil'. Section 4 recognizes and discusses that the two markets differ substantially, in particular concerning the Russian Federation.

[7] 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.

[8] The analysis could be adjusted to account for extraction cost or a consumption tax on oil or gas.

[9] We might account for intertemporal consumption preferences and write this as an intertemporal utility function

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

With complete financial markets, this does not make much of a difference but can affect the outcome if insecure property rights are introduced, as we do 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.

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

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

where X is total demand in period 1 and Y is total demand in period 2. The parameter ϵ denotes the absolute elasticity of demand; we assume that demand is elastic: $\epsilon > 1$.[10]

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

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

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*

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

[10] 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.

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

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

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

$$(x_I, y_I) = \begin{cases} (s_I, 0) & \text{if} \quad p_1(1+r) > p_2 \\ (x_I, y_i) \in \Sigma_1(s_I) & \text{if} \quad p_1(1+r) = p_2 \\ (0, s_I) & \text{if} \quad p_1(1+r) > p_2 \end{cases}$$

where $\Sigma_1(s_I)$ 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

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

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 holds making 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 group W maximizes present value of revenues

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

by its choice of $x_W \in [0, s_W]$ and is, for this purpose, a price taker.

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 $\delta \in [0, 1]$.[11] This probability is exogenous in the context here.[12] 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.[13] 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, Olson, and Schöb (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 on 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 $\lambda > \delta$. 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.[14] The present value of expected payoffs

[11] 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.

[12] See Acosta (2018) for a model where the expropriation risk in endogenous and depends on the oil wealth in the ground.

[13] The assumptions about appropriation and insecure power can be relaxed, for instance, giving the autocrat only a given 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).

[14] 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).

to the autocrat as a function of x_A can be written as

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

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

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

where $\Sigma_1(s_W)$ 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

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

and

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

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*

$$s_W > s \cdot \frac{\alpha_1 \cdot (1+r)^{\epsilon}}{\alpha_1 \cdot (1+r)^{\epsilon} + \alpha_2}. \tag{6}$$

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 (6). ■

Note that (6) 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 in the case without sanctions and in the case with 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

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

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.

4 Lessons for the Ukrainian conflict

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.

Zero first-order effects The first insight is on an oil or gas 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, provided that the embargoed country is "small" in comparison to the overall market, i.e., if the remaining other suppliers can change their extraction path to compensate for the delayed extraction by the embargoed country. These countries voluntarily compensate for the supply shortfall and without changing their present value of overall profits. As a result, the aggregate extraction path and the aggregate price path, as well as the payoffs of all parties involved, remain entirely unaffected. The intuition behind this neutrality 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 to one country, this prevents the country from exchanging one asset into another one but does not reduce the country's wealth. Now, any foregone profits from oil sales are not really losses, as the asset remains in the ground.

To get an idea about numbers: the Russian Federation has a share of 6.2 percent of proven world oil reserves and a share of 19.9 percent of proven gas reserves at the end of 2020 (BP 2021, pp. 16 and 34). Globally this makes it a player of only intermediate size in the market for oil and a more significant, but not a dominant player in the market for natural gas. Given that the Russian federation contributes about 12.6 percent to global oil supply and 16.6 to global gas supply (BP 2021, pp. 19 and 36), and annual worldwide production is only 1/48 of total proven gas reserves and 1/54 of total proven oil reserves, it is evident that the world would have to make a minor shift in production patterns to compensate for the embargo for several years.

Insecure property rights: an embargo hurts An export embargo can hurt an authoritarian government in the embargoed country, even if the international market for oil reserves is perfectly fungible (regionally and intertemporally). 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.[15] The embargo forces the government of such a country to involuntary 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 and will then not enjoy the fruits of future extraction. We can again look at the BP (2021) data. The Russian Federation extracts much faster among the larger countries holding oil reserves than them. It extracts with about twice the speed in comparison to the world. While the World has a ratio of reserves to production of 53.5, the Russian Federation has a ratio of 27.6, suggesting that Russia is, in fact, in a rush. The results for natural gas are less straightforward. The ratio of reserves to production is 58.6 in the Russian Federation and 48.8 overall (BP 2021, pp. 16 and 34). This means that Russia exploits its oil fields about twice as fast as other countries on average and exploits its gas fields slightly slower than the world does on average.[16]

Sluggish supply adjustments The previous considerations were based on an analysis of an intertemporal equilibrium under ideal conditions. Of particular

[15] The Hotelling literature has discussed these incentives from a theory perspective, and Merrill and Orlando (2020) provide empirical evidence for oil producers who behave in line with the theoretical argument.

[16] Note that the ratio of reserves to production is an incomplete proxy for the rush-to-burn phenomenon. With extraction costs, the Hotelling rule requires that the resource rent – rather than the price – increases with the world interest rate. As the resource rent is the difference between the market price and the extraction cost, countries with lower extraction costs exploit their resources earlier. Other things being equal, these countries exhibit lower reserves-to-production ratios.

importance here are the full foresight of the actors involved and the possibilities for flexible adjustments of the intertemporal extraction path to sudden changes, in particular the desired adjustments to shocks such as a possible temporary export embargo of a single supplier.

Even with frictions, the situation is not desperate for resource-consuming countries. Many OECD countries have strategic crude oil reserves for several months. Since the individual failing supplier typically accounts only for a fraction of demand in a country, together with continued imports from other sources, these strategic reserves will last longer to compensate for the shortfalls, perhaps long enough for world production to compensate for the 12.6 percent shortfall in supplies originating from Russia and redirecting the oil tanker fleet accordingly.

The situation in the market for natural gas could be more difficult. Here, Russia has a much larger share of the world market, accounting for 16.2 percent of annual production (end of 2020, BP 2021). Moreover, the supply routes used to transport natural gas from the gas fields to consumers are far less fungible than is the destination of oil tanker fleets. It is, therefore, reasonable to assume that adjustments to the failure of such a significant supplier will involve severe dislocations. For a deeper study, a dynamic market for gas, accounting for the capacity limits in existing networks and LGT trade, as well as the options for dynamic adjustments, would be needed.

5 Conclusions and policy implications

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 or natural gas 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 is missed in the debate about export embargoing autocrat governments' natural resource exports.

References

[1] Acosta, Mauricio Rodriguez, 2018, Resource management under endogenous risk of expropriation, Resource and Energy Economics 52, 1-17.

[2] Alexseev, Mikhail A., and Henry E. Hale, 2020, Crimea come what may: Do economic sanctions backfire politically?, Journal of Peace Research, 57(2), 344-359.

[3] Andermo, Erik, and Martin Kragh, 2021, Sanctions and dollar dependency in Russia: resilience, vulnerability, and financial integration, Post-Soviet Affairs, 37(3), 276-301.

[4] Anderson, Soren T., Ryan Kellogg and Stephen W. Salant, 2018, Hotelling under pressure, Journal of Political Economy, 126(3), 984-1026.

[5] BP, 2021, Statistical Review of World Energy 2021, 70th edition.

[6] Brander, James. A., 1995, Strategic trade policy, Handbook of International Economics, 3, 1395–1455.

[7] da Cunha, Roberto Ferreira and Antoine Missemer, 2020, The Hotelling rule in non-renewable resource economics: A reassessment, Canadian Journal of Economics, 53(2), 800-820.

[8] Dreger, Christian, Konstantin A. Kholodilin, Dirk Ulbricht and Jarko Fidrmuc, 2016, Between the hammer and the anvil: The impact of economic sanctions and oil prices on Russia's ruble, Journal of Comparative Economics, 44, 295-308.

[9] Early, Bryan R., and Menevis Cilizoglu, 2020, Economic sanctions in flux: enduring challenges, new policies, and defining the future research agenda, International Studies Perspectives, 21(4), 438–477.

[10] Eaton, Jonathan, and Maxim Engers, 1992, Sanctions, Journal of Political Economy, 100(5), 899- 928.

[11] Eaton, Jonathan, and Maxim Engers, 1999, Sanctions: Some simple analytics, American Economic Review, 89(2), Papers and Proceedings, 409-414.

[12] Edwards, Jeremy, and Michael Keen, 1996, Tax competition and Leviathan, European Economic Review, 40(1), 113-134.

[13] Farzanegan, Mohammad Reza, and Mozhgan Raeisian Parvari, 2014, Iranian-Oil-Free Zone and international oil prices, Energy Economics 45, 364-372.

[14] Felbermayr, Gabriel, T. Clifton Morgan, Constantinos Syropoulos, and Yoto V. Yotov, 2021, Understanding economic sanctions: Interdisciplinary perspectives on theory and evidence, European Economic Review, 135, 103720.

[15] Hotelling, Harold, 1931, The economics of exhaustible resources, Journal of Political Economy, 39, 137–175.

[16] Janeba, Eckhard, 2022, Extraterritorial trade sanctions: Theory and application to the US-Iran-EU conflict, CESifo Working Paper No. 9573.

[17] Kaempfer, William H., and Anton D. Lowenberg, 1988, The theory of international economic sanctions: A public choice approach, American Economic Review, 78(4), 786-793.

[18] Konrad Kai A., and Kjell Erik Lommerud, 2021, Effective climate policy needs non-combustion uses for hydrocarbons, Energy Policy, 157, 112446.

[19] Konrad Kai A., Trond E. Olsen, and Ronnie Schöb, 1994, Resource extraction and the threat of possible expropriation: The role of Swiss bank accounts, Journal of Environmental Economics and Management, 26(2), 149-162.

[20] Kwon, Ohyun, Constantinos Syropoulos, and Yoto V. Yotov, 2022, The extraterritorial effects of sanctions, CESifo Working Paper No. 9578.

[21] Long, Ngo Van, 1975, Resource extraction under the uncertainty about possible nationalization, Journal of Economic Theory, 10(1), 42-53.

[22] Merrill, Ryan K. and Anthony W. Orlando, 2020, Oil at risk: Political violence and accelerated carbon extraction in the Middle East and North Africa, Energy Economics 92, 104935.

[23] Okullo, Samuel J., Frédeéric Reynès, and Marjan W. Hofkes, 2015, Modeling peak oil and geological constraints, Resource and Energy Economics, 40, 36-56.

[24] Özdamar, Özgür, and Evgniia Shahin, 2021, Consequences of economic sanctions: The state of the art and paths forward, International Studies Review, 23(4), 1646-1671.

[25] Peksen, Dursun, 2019, When do imposed economic sanctions work? A critical review of the sanctions effectiveness literature, Defence and Peace Economics, 30(6), 635-647.

[26] Scazzieri, Luigi, 2017, Europe, Russia and the Ukraine crisis: the dynamics of coercion, Journal of Strategic Studies, 40(3), 392-416.

[27] Slade, Margaret E., 1982, Trends in natural-resource commodity prices: an analysis of the time domain, Journal of Environmental Economics and Management, 9(2), 122-137.

[28] Stiglitz, Joseph E., 1976, Monopoly and the rate of extraction of exhaustible resources, American Economic Review, 66(4), 655–661.

[29] Tostensen, Arne, and Beate Bull, 2002, Are smart sanctions feasible? World Politics, 54(3), 373-403.

[30] Tsebelis, George, 1990, Are sanctions effective? Journal of Conflict Resolution, 34(1), 3-28.

[31] Tuzova, Yelena, and Faryal Qayum, 2016, Global oil glut and sanctions: The impact on Putin's Russia, Energy Policy, 90, 140-151.

[32] Venables, Anthony J., 2014, Depletion and development: Natural resource supply with endogenous field opening, Journal of the Association of Environmental and Resource Economists, 1(3), 313-336.