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Introducing a price cap on Russian gas

A game theoretic analysis

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1. Introduction

Russia's military invasion of Ukraine has been a watershed moment for the political order in Europe and is leading to a complete reassessment of the energy policy of the European Union (EU). While the abundant availability of Russian pipeline gas had kept natural gas prices low in the EU over the last decades and contributed to the EU's energy intensive industries' competitiveness, the current crisis has laid bare the dependency of the EU (and in particular of certain EU Member States, such as Germany, Austria, Bulgaria, Slovakia, Slovenia, the Czech Republic and Hungary) on the reliability of Russia as a supplier.

Starting already ahead of the actual military invasion, reduced Russian supplies¹ and the corresponding market reaction lead to a five-fold gas price increase to 97 €/MWh for the period October 2021 to June 2022, compared to a long-term average of 19 €/MWh for the ten preceding years (TTF spot market).² While the gas price had in the meantime come down from its all-time peak of 227 €/MWh shortly after the invasion to 77 €/MWh by May, Gazprom's reduction of gas flows through the Nord Stream 1 pipeline to 40% of capacity in the beginning of June has increased gas prices again to around 170 €/MWh by the first week of July. As gas supply contracts of European buyers from Russia are typically linked to the spot market price, this means for the latest cuts with EU gas prices more than doubling, Russia's corresponding revenues might have stayed nearly constant, despite significantly reduced volumes sold. In the

¹ Gazprom completely stopped voluntary spot market deliveries in October 2021 after already having supplied significantly less than usual during all of summer 2021. After the invasion, Russia also started to cut supplies to long-term contract holding entities on 27 April 2022 with cuts to Poland and Bulgaria, followed by cuts to the Netherlands, Greece, Denmark, and Finland as well as reductions to Germany, Italy, France, Czech Republic, Slovakia and Austria later in spring and early summer 2022 (McWilliams & Zachmann, 2022).

² Using day-ahead prices of Europe's most liquid gas hub TTF (Netherlands), the average price for the affected period from October 2021 to July 2022 was 97.57 €/MWh. Compared to the long-term average of 19.27 €/MWh in the ten years preceding 2021, i.e. 2011-2020, this constitutes a 5.06-fold increase. The last pre-covid year, 2019, had an average price of 13.56 €/MWh. Comparing to 2019, the recent elevated period (October 2021-July 2022) even constitutes a 7.2-fold increase.

current price environment, Russia is thus hurting the EU economically at a very low cost to its own revenue stream. Uncertainty and price increases in the natural gas market, and more broadly in all energy markets, have in fact increased the overall energy-related revenues to the Russian federal budget.³

This has led to a policy discussion of what the most appropriate EU policy reaction should be.⁴ The debated policy options for the energy sector range from an outright embargo,⁵ the introduction of tariffs, to the imposition of an external price cap towards Russian oil and gas exports. While many scholars point to tariffs as a preferred instrument (e.g. Hausmann et al., 2022; Gros, 2022; Sturm 2022a), which make particular sense in the case of oil (Sturm et al. 2022b), for the case of gas we observe a consensus emerging towards an external price cap (e.g. Riley, 2022, Zachmann & Ockenfels, 2022).⁶ This is due to the structure of the EU-Russia gas market, where Russia holds a monopoly over the EU's residual gas demand, while the EU, if it would engage in joint procurement, has market power itself and could act as monopsony. Given that market structure, we consider a price cap to be the more appropriate policy instrument compared to a tariff, because a price cap tends to take away the economic incentives for Russia to use its market power to increase gas prices. Under these circumstances, it can be shown that an external price cap is superior to a tariff in the sense that for any tariff there exists a price cap that makes both the EU and Russia better off (Ehrhart et al. 2022).⁷ Consequently, the EU can always design a price cap that gives Russia the same welfare (so it is equally likely to accept), but makes the EU better off compared to imposing a tariff.

The purpose of this paper is to study the strategic implications and feasibility of imposing the cap vis-à-vis Russia. The purpose is not to go into details of the EU internal implementation of an external price cap for Russian gas. Nevertheless, we would like to point out that for a price cap on Russian gas to work, the EU will have to act as a single buying entity towards Russia.⁸ Assuming Russia accepts the price cap, a European buying entity will have to centrally procure, and then offer the Russian gas into EU gas spot markets. The potential difference between spot market revenues and the price paid towards Russia would accrue as additional income at the European level. EU countries will then have to agree on how to distribute the income made from the price differential.⁹ As technical implementation of an external price cap seems

³ Based on data by the Russian Ministry of Finance (2022).

⁴ See e.g. Riley (2022), Gros (2022), International Working Group on Russian Sanctions (2022).

⁵ In May 2022, the EU agreed on a ban on imports from Russia of crude oil and refined petroleum products (with limited exceptions) by the end of the year, while no measures have been agreed on natural gas, so far (European Council, 2022a).

⁶ In its 24 June meeting, the European Council has also tasked the European Commission to explore temporary import price caps (European Council, 2022b).

⁷ Note that the price cap on Russian gas analysed here is crucially different in its dynamics from the price cap for oil recently discussed by G7 leaders. Lacking a central buyer, the oil price cap is hard to enforce and offers a multitude of possibilities for side-payments and selection of benefitting buyers by Russia. This is not the case for an external price-cap on Russian gas implemented with the EU as a central buyer, since the EU holds a monopsony for Russian gas from the Western Siberian gas fields.

⁸ During the 24 and 25 March European Council the EU agreed on possible joint natural gas purchases through the EU Energy Platform (European Council, 2022c).

⁹ If Russia would offer large quantities at the price cap, spot prices could fall to the level of the price cap, so that there is no additional income to be distributed, as supply shortages are relieved. By re-selling the procured Russian

feasible,¹⁰ we try to shed light on the larger strategic question of whether, and under what conditions, the external price cap can work in the outward relationship with Russia.

In this short essay, we argue that under certain conditions an external price cap is the optimal policy choice. To arrive at this conclusion, we use a simple game theoretic analysis that looks at the possible outcomes of a sequential game. To maximise the generality of the derived results, the utilities (payoffs) of the EU and Russia are ordinally scaled and mutually non-comparable, so that simple comparisons of the scenarios along the lines of "which is better" are possible without using cardinal utilities and without the need to compare the payoffs of the EU and Russia. The aim of this analysis is to provide decision makers in the EU with basic but rigorous conclusions that can help shape policy options to maximise the outcome of the possible standoff following the EU's introduction of an external price cap on Russian natural gas.

2. Why is a game-theoretical analysis the appropriate approach?

Applying game-theoretical analysis to the EU-Russia gas market interaction makes possible to describe and analyse the strategic interactions between the EU and Russia. This can be done by modelling a game involving utility-maximising players with foresight allowing them to derive the expected outcomes of their strategic interaction. A central element is the identification and description of the players' strategies. Every strategy of a player is a complete behavioural plan for the game, giving the player instructions for choosing an action for each decision situation the player may encounter in the game. By comparing all the players' possible strategic combinations, strategically stable solutions, so-called game-theoretical equilibria, can be identified. A game-theoretical equilibrium is to be considered strategically stable in the sense that the players' equilibrium strategies are mutually best responses. Thus, under the assumption of rational players who take the entire game into account, players can be expected to end up in a game-theoretic equilibrium. Building on this, the game-theoretic approach can be used to examine how changes in the structure of the game, the information structure and the players' utilities (i.e. their individual evaluations of the outcomes of the game) affect the expected solutions and thus the final outcome of the game. A further strength of the game theoretic approach lies in the fact that it allows to compare and evaluate different games in terms of their outcomes for a player. On this basis, the best potential game for a player (which the player can shape within its possibilities) can be identified, allowing to derive policy implications. The motto here is: change the rules of the game (including the players' payoffs) to your advantage!

3. The EU-Russia gas market in a game theoretic analysis

We model the policy options of the EU and Russia in a two-player sequential non-cooperative game with complete and perfect information. This includes that the players' policy options (actions) and their utilities (payoffs) are common knowledge and that both players can observe the decisions of the other player. The individual utilities comprise multiple individual

gas into EU spot markets at a slight premium to the externally capped price, the European buying entity could make sure to at least cover its own administrative costs.

¹⁰ The existence of centralized EU gas spot markets facilitates implementation of a single EU buying entity as procured volumes could simply be offered into these markets. Riley (2022) makes further suggestions such as calling force majeure on existing long-term supply contracts.

dimensions, i.e. own economic welfare, destruction of the adversary’s economic welfare, political short- and long-term considerations, etc. The two players, the EU and Russia, are assumed to act rationally and maximize their utility. To simplify the analysis, we reduce Russia’s choice to gas delivery or non-delivery, assuming the delivery choice includes the quantitative optimisation of a monopolist.

Description of the game

The game is described by the game tree in Figure 1, where blue circles with EU_i denote EU decision nodes and the red circle with RU_1 Russia’s decision node. Starting from the initial situation in which Russia maximises its monopoly rents, the EU has two options in decision node EU_1 , either to continue paying Russia's high prices or to impose a price cap as the maximum price it is willing to pay for any Russian gas supplied. The first choice is maximising Russia’s welfare and leads to the terminal node z_1 with the utilities e_1 for the EU and r_1 for Russia. The second choice leads to decision node RU_1 in which Russia has the choice of either complying with the EU ultimatum of a price cap leading to the terminal node z_2 with the utilities e_2 (EU) and r_2 (Russia) or to threaten a delivery stop. This leads to the EU’s decision node EU_2 where the EU has the choice of either giving in to Russia’s threat and continue to pay the high prices, leading to the terminal node z_3 with the utilities e_3 (EU) and r_3 (Russia), or to stay firm and except the consequences of a full gas delivery stop. The latter choice leads to the terminal node z_4 with the utilities e_4 (EU) and r_4 (Russia).

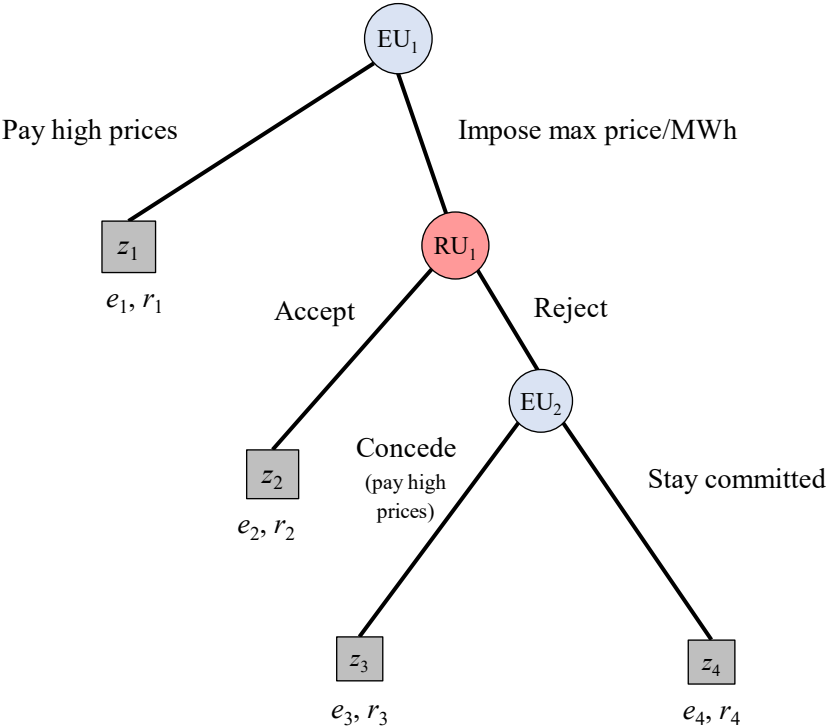


Figure 1: Game tree of the EU-Russia gas game

Ranking the order of outcomes

We analyse the game using the game-theoretic solution concept of subgame-perfect equilibrium (SPE) in pure strategies.¹¹ Here, the use of ordinal-scaled instead of cardinal-scaled individual utility values e_i (EU) and r_j (Russia) allows for a more general application. We assume a fixed order of preferences for e_1, e_2 , and e_3 for the EU and for r_1, r_2 , and r_3 for Russia. We do not fix the placement of e_4 and r_4 in the preference order, as we will analyse different scenarios regarding their placement in the order and how consequently equilibria are affected.

We assume the following order of preferences (excluding the outcome of z_4 for now):

EU: Russia accepts EU price cap (best EU outcome, e_2) is
better than the current high price situation (second best outcome, e_1) is
better than EU gives in to Russia's threat of delivery stop (worst outcome, e_3)

Formally: $e_2 > e_1 > e_3$

Russia: EU gives in to Russia's threat of delivery stop (best RU outcome, r_3) is
better than the current high price situation (second best outcome, r_1) is
better than Russia accepts EU price cap (worst outcome, r_2)

Formally: $r_3 > r_1 > r_2$

The best outcome for the EU of the ones pre-defined here (i.e. without making a statement yet about where to place e_4 and r_4 in the preference order) is e_2 (Russia accepts EU price cap), the best outcome for Russia is r_3 (having forced the EU to abandon its price cap ultimatum threat). The worst outcome for the EU is e_3 (EU gives in to Russia's threat of delivery stop), while the worst outcome for Russia is r_2 (Russia accepts EU price cap). Thus, the current situation with utilities e_1 and r_1 is the second-best option, both for the EU and Russia.

¹¹ The subgame perfect equilibrium (or subgame perfect Nash equilibrium) is a refinement of a Nash equilibrium for sequential games (Selten, 1965). Definition: A strategy profile is a subgame perfect equilibrium if it represents a Nash equilibrium of every subgame of the original game (e.g. Fudenberg and Tirole, 1991). Every subgame perfect equilibrium is a Nash equilibrium but not vice versa. The subgame perfect equilibrium solves the rationality problems that can arise with the Nash equilibrium, such as credible threats.

Game-theoretic solutions in relation to the ordinal utility ranking of a gas delivery stop

Assuming the above order of preferences $e_2 > e_1 > e_3$ and $r_3 > r_1 > r_2$, the SPE and hence the outcome (terminal node) of the game depends on where in the ordinal ranking the utilities e_4 and r_4 of the terminal node z_4 (Russian gas delivery stop following the EU demand for a price cap on Russian gas) are placed.

Already this simplistic game setup and looking at possible rankings of e_4 and r_4 with respect to e_1, e_2, e_3 and r_1, r_2, r_3 allows for several non-intuitive conclusions.

We determine the SPEs for the game by backwards-induction: Starting with the subgame from the decision node EU_2 , it becomes apparent that the decision of the EU in EU_2 depends on the ratio of e_3 and e_4 . If $e_3 > e_4$, the EU will go to the left in EU_2 (concede), if $e_3 < e_4$, to the right (stay committed). Since e_3 and e_4 are commonly known, both players correctly predict the decision of the EU in EU_2 and take it into account accordingly in their strategic calculations. Therefore, for Russia's decision in node RU_1 , it compares r_2 with its expected outcome in the subgame from EU_2 , which, as described before, depends on the ratio of e_3 and e_4 . In case of $e_3 > e_4$, Russia compares r_2 with r_3 for its decision: If $r_2 > r_3$, Russia will go to the left in RU_1 (accept price cap), if $r_2 < r_3$, to the right (reject price cap). If $e_3 < e_4$, Russia compares r_2 with r_4 : If $r_2 > r_4$, Russia will go to the left in RU_1 (accept price cap), if $r_2 < r_4$, to the right (reject price cap). Finally, the EU's decision in EU_1 is considered as a function of the previously derived decisions in the subgames starting in RU_1 and starting in EU_2 . Therefore, the EU decides via comparison with e_1 whether to go to the left in EU_1 (pay high prices) or to the right (impose max price).

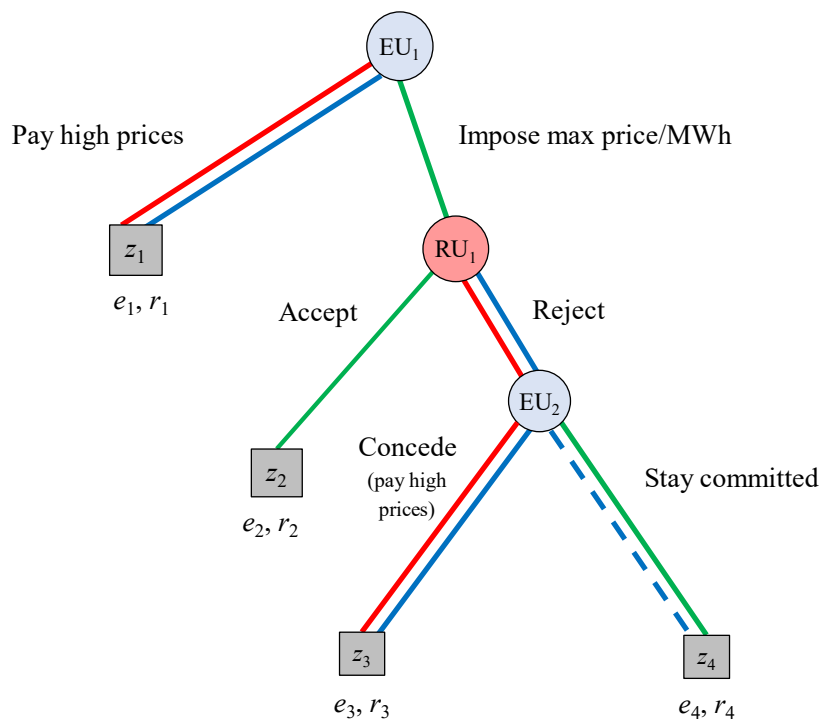


Figure 2: The subgame-perfect equilibria for different scenarios in the EU-Russia gas game

Based on the game in Figure 2 and the assumed preference orders $e_2 > e_1 > e_3$ and $r_3 > r_1 > r_2$, we now consider some different scenarios and determine the SPE in each case depending on the full preference order of the EU and Russia. For better illustration, the three scenarios considered relevant, 3, 4, and 5, are marked in different colours, as are the actions of the corresponding players' SPE strategies in the game in Figure 2.

Scenario 1: $e_4 > e_1$ and $r_4 > r_2$

SPE $\rightarrow z_4$ (Russia rejects the EU price cap and EU stays committed)

Scenario 2: $e_4 > e_1$ and $r_4 < r_2$

SPE $\rightarrow z_2$ (Russia accepts EU price cap)

Scenario 3: $e_3 < e_4 < e_1$ and $r_4 < r_2$

SPE $\rightarrow z_2$ (Russia accepts the EU price cap)

Scenario 4: $e_4 < e_3$ and $r_4 < r_2$

SPE $\rightarrow z_1$ (EU continues to pay high prices)

Scenario 5: $e_4 < e_1$ and $r_4 > r_2$

SPE $\rightarrow z_1$ (EU continues to pay high prices)

We discard Scenario 1 and 2, as these would require the EU to prefer a gas delivery stop over the current situation, which it could already unilaterally achieve by stopping to buy gas from Russia, but we can observe that it has so far chosen not to do so. We also do not define further scenarios with $r_4 > r_1$, since these are redundant to the scenarios above, as Russia never gets to choose between r_1 and r_4 and since r_1 is always larger than r_2 given our assumed preference order. The remaining 3 scenarios are within the realm of the assumed preference orders, non-redundant, and not contradicting observable facts.

Under **Scenario 3**, even if the EU values the current situation more than a Russian gas delivery stop ($e_4 < e_1$) and if the EU prefers to stay firm following a Russian rejection of its price ultimatum ($e_4 > e_3$), the SPE leads to z_2 , i.e. Russia will comply with the EU price cap, in case Russia is worse off under a gas delivery stop than under the compliance with the EU price cap ($r_4 < r_2$).

On the other hand, under **Scenario 4** it would not be rational for the EU to threaten a price cap, if it cannot credibly commit to stay firm following a Russian rejection of its price ultimatum ($e_4 < e_3$), even if Russia is worse off under a gas delivery stop than under compliance with the EU price cap ($r_4 < r_2$). Thus, the SPE leads to z_1 (status quo).

Scenario 5 shows that if the EU is worse off under the Russian gas delivery stop compared to the current situation ($e_4 < e_1$), as long Russia is better off under a gas delivery stop than under compliance with the EU price cap ($r_4 > r_2$), it would also not be rational for the EU to threaten a price cap. Thus, also in this scenario the SPE leads to z_1 . The ratio of e_4 and e_3 does not matter in this scenario. Therefore, there exist two SPEs, one for $e_4 < e_3$ (solid blue line) and the other for $e_4 > e_3$ (dotted blue line), which both lead to the same outcome z_1 .

4. Policy implications

The scenario analysis above reveals that under certain conditions it is rational for Russia to comply with an EU imposed price cap on Russian gas. It will do so, if the EU can (1) credibly commit to stay firm following a Russian rejection of its price ultimatum and (2) in case Russia considers it is worse off under a gas delivery stop than if complying with the EU price cap. This allows EU policy makers to preemptively consider policies that will strengthen their hand in the possible standoff with Russia following the introduction of an EU external price cap for Russian gas. Figure 3 shows where EU policy could potentially make a difference in achieving Russian compliance with an EU external gas price cap (see intervention points with blue arrows).

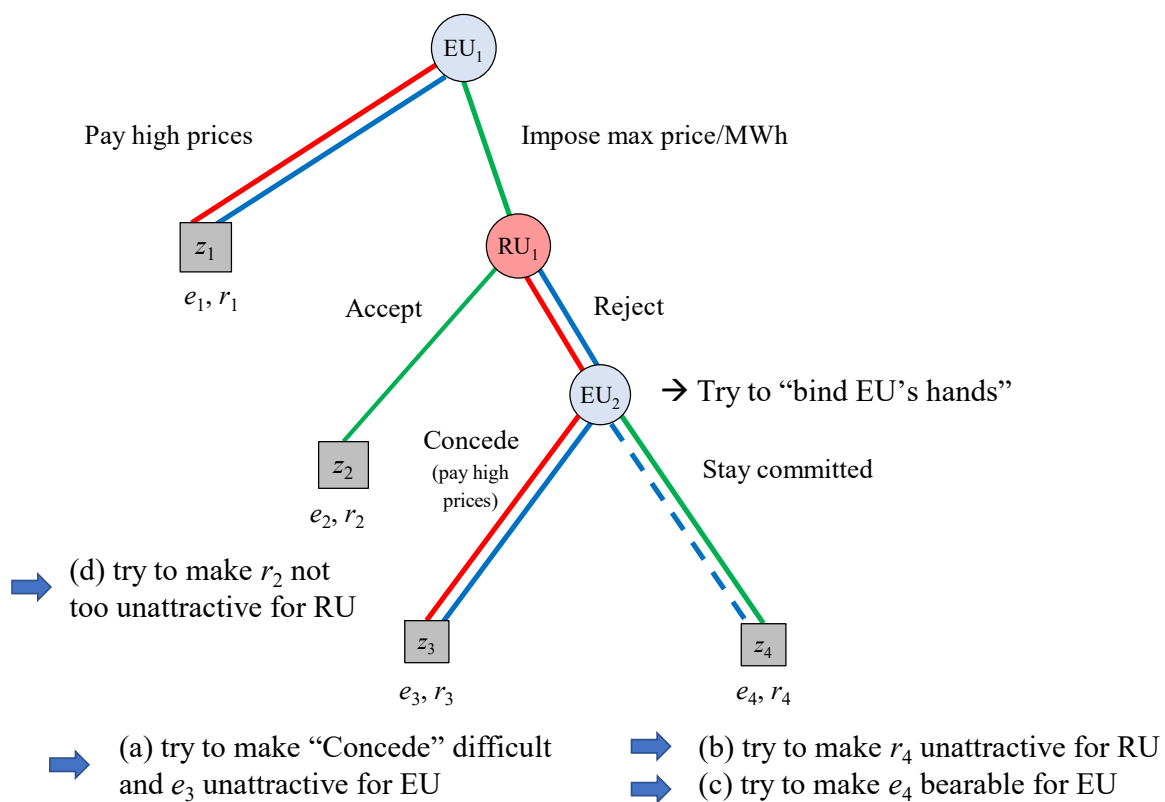


Figure 3: Game tree of the EU-Russia gas game with policy action points for the EU

In principle, four possible policy intervention points can be considered to increase the likelihood of the desired outcome, i.e. Russian compliance with an EU imposed price cap on Russian gas.

These policy intervention points are:

- a) The EU should try to make its own backpedaling from a price ultimatum as difficult as possible. This could be achieved by credible political signaling to both the EU domestic audience and to Russia that once it has announced its price ultimatum, the EU will not waver (“locking in policy choices”). It is probably the most difficult set of policies to

achieve, given EU unanimous decision making on sanctions and EU Member States diverging national energy policies – but once unanimity is achieved, it could have, at least under EU-law, the desired lock-in effect as unanimity would equally be needed to backtrack from the price ultimatum.

- b) The EU should try to make a gas embargo more painful for Russia. This could, for example, be achieved by threatening further sanctions in case Russia stops gas deliveries to the EU.
- c) The EU could try to make a Russian gas embargo more bearable for itself. While a Russian gas delivery stop to the EU will in any case be a challenge for the EU economy and a test of EU Member States internal and intra EU cohesion, measures that at least partially alleviate the economic and social hardship, as well as additional efforts to replace Russian gas by as much non-Russian gas as possible, efforts to faster switch the energy mix to non-Russian fossil¹² and renewable energy sources or energy saving and domestic and intra-EU solidarity emergency plans all can help to limit the damage a Russian gas embargo would have on the EU.
- d) Lastly, the EU should try to make a price cap acceptable to Russia. This could, for example be achieved by a reasonably high level of the price cap, which covers the Russian extraction costs and leaves a profit margin. Other policies, such as non-aggressive communication on the price cap, could aim at helping the Russian leadership to lose as little face as possible vis-à-vis its domestic and international audience when accepting the cap.

The above non-exhaustive catalogue is by no means an automatic recipe for success of an external price cap, not least because the underlying analytical framework assumes rationality of all actors. Nevertheless, and despite its simplicity, we think the analysis can help structuring the debate around measures necessary to increase the chances of successful implementation of an external price cap on Russian gas.

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¹² The recent decision of Germany and the Netherlands to reactivate idle coal-burning electricity plants can be considered such a measure.

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