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Working Paper

Price cap versus tariffs: The case of the EU-Russia gas market

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Abstract

To counter rising gas prices and corresponding Russian profits, many scholars point to import tariffs on Russian gas as a preferred policy instrument. While this makes sense in the case of oil, for the case of gas we observe the opposite. This is due to the structure of the EU-Russia gas market, where Russia holds a monopoly over the EU's residual gas demand and the EU, if it would engage in joint procurement, has market power itself potentially acting as monopsony. However, it has not yet chosen to exercise its market power. Under these conditions, an external price cap for Russian gas can be considered to be the more appropriate policy instrument, because a price cap tends to take away economic incentives for Russia to use its market power, increasing gas prices through decreasing supply. Under such circumstances, we show 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. 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.

1 Introduction

The Russian invasion in Ukraine and the deliberate cut in supply of Russian gas has led to unprecedented price hikes on the EU gas market. Against the 10-year pre-COVID average, representative TTF gas prices have increased around tenfold. The average of TTF gas prices from 2010-2019 was 20.07 EUR/MWh, less than a tenth of the 204 EUR/MWh at the time of this writing, on 28 July 2022. This has led to a policy discussion in Europe on the appropriate response with various different policies being proposed, mainly the introduction of tariffs (e.g. Gros 2022; Hausmann et al. 2022) and external price caps (e.g. Martin and Weder di Mauro 2022 or Italian prime minister Mario Draghi's price cap proposal, see Bloomberg 2022).

While both policies can increase EU welfare, in this short paper we explain why the policy instrument of an external price cap,[1] has advantages for the EU over the introduction of a tariff in the EU-Russian natural gas market. While in particular for the oil market a tariff can be seen as an appropriate instrument to curb Russian profits (Sturm et al. 2022; Hausmann et al. 2022), our analysis reveals that this is not the case for the EU-Russia gas market. The key difference is Russia's market power over the EU's residual demand, which in some EU Member States' cases, such as Germany, cannot be physically replaced in the short-term by any other supplier. At the same time, given the existing pipeline infrastructure, the EU is currently the only potential foreign buyer of Russian gas from the Western Siberian gas fields, but has so far not chosen to exercise its resulting market power in the form of a monopsony.

While in the context of its war against Ukraine Russia certainly has additional strategic goals than profit and welfare maximisation, it remains important to understand Russia's economic incentives as these are likely to enter into any broader strategic considerations and it can be assumed that they are at least partially influencing Russian decision making. Studying economic incentives also provides answers on preferable policy instruments for the EU trying to minimise the negative economic impacts on itself.

In this paper, we first describe Russia's economic incentives as a monopolist on EU gas markets (Section 2), then we show how the introduction of tariffs (Section 3) and a price cap (Section 4) change the resulting prices and quantities in the EU-Russia gas trade, before showing that a price cap is superior compared to a tariff that makes Russia at least equally well off in welfare terms (Section 5).

[1] The external price cap towards Russia discussed here is not to be confused with a domestic price cap on gas. While an external price cap is a form of trade-policy, a domestic price cap is a market intervention that is aimed at domestic markets and leads to a non-clearing domestic market immediately, requiring regulatory rationing.

2 Russia as a gas monopolist

Russia has substantial market power in the EU natural gas markets: By its actions, it can influence EU hub prices. Because the prices paid under existing supply contracts are usually indexed to spot prices on EU gas markets (Fulwood et al. 2022), Russia benefits from such influence on prices. It is thus in Russia's interest to limit the supplied quantity in a similar way a monopolist does by limiting quantities and raising prices to increase its profits. Russia has successfully demonstrated its power to influence EU gas prices since mid-2021.

A simplified example of Russian profit maximization is shown in Figure 1. Even if Russia is not the only gas supplier to the EU and there is some competition from liquefied natural gas (LNG) supply, it is helpful for illustrative purposes to assume Russia as a monopolist facing a residual demand curve already incorporating residual supplies. Given LNG regasification terminals in Europe are already running near capacity (Commission 2022), LNG supply will not be able to provide much additional relief above current levels, which underlines the role of Russia as a monopolist on the residual demand.

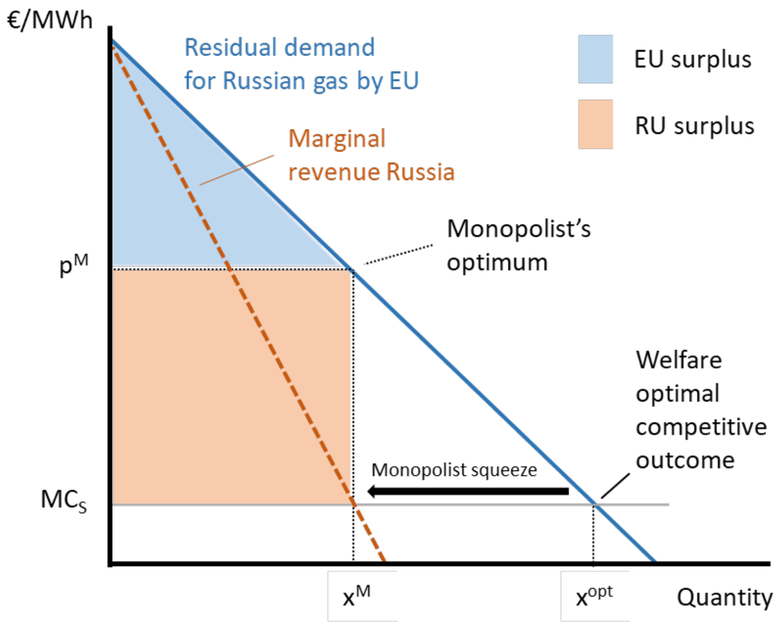

Figure 1: Benchmark: Russia as a monopolist. Low quantities, high prices.

European demand for gas, on the other hand, is so far not bundled. The EU could choose to jointly purchase gas through a single buying entity leveraging its own market power, but as long as that is not the case, the correct analytical structure to apply is a model of competitive buyers facing a monopolistic residual supplier. Later in this paper, we will analyse the potential effects of EU exercising its market power through joint gas purchases.

A monopolist facing competitive buyers takes its own influence on prices and quantities into account when making supply decisions and regards the price as a function of its own supplies. Russia as a monopolist would thus supply up until the point where marginal revenue (and not the demand curve) equals its own marginal cost, which in the case of Russian gas extraction we assume to be reasonably close to constant. Thereby, the supplied quantity is reduced from the competitive level x^{opt} to the monopolist's preferred level x^M and the price increases from the marginal cost level MC_s to the monopolist's optimum p^M. Hence, Russia would maximize its producer surplus, which equals Russian welfare (depicted in red). The resulting smaller EU consumer surplus (which here equals EU welfare) is depicted in blue.

Note that the chosen shape of the demand curve is extremely stylized and is by no means representative of the actual European demand curve which is likely to be extremely inelastic, which would increase the leverage a monopolist has on domestic price levels even further.

3 Tariffs on Russian gas

Now, consider the introduction of a tariff (Figure 2). The example shows a simple per-unit tariff levied on Russian gas.[2] Even though Russian profits decrease (and the EU domestic price increases), the main incentives are the same: the monopolist again optimizes for its own profits and supplies even less. While this has the desired effect of reducing Russian profits, it also causes even more severe shortage of gas in Europe as supplies would be further reduced. This also causes the domestic price to rise above the level that was prevalent prior to the introduction of the tariff.

Looking at the welfare effects for Russia following the introduction of an EU tariff on Russian gas, we can see that Russian welfare (red rectangle) has declined in Figure 2 compared to Figure 1. The tariff had the intended effect of making Russia worse off. As a result of higher prices, EU consumer surplus also declines following the introduction of the tariff (the blue triangle is reduced). At the same time, the EU collects tariff revenue (depicted in green), which adds to EU welfare. Assuming the tariff revenue can be used to compensate EU gas consumers and that the EU values one euro of tariff revenue equally to one euro of EU gas consumer surplus, the EU is better off following the introduction of a tariff on Russian gas. Consequently, the introduction of optimal tariffs (Sturm 2022) on Russian gas is better for the EU in welfare terms than the current status quo - although supply shortage is aggravated, which, in the monopolistic gas setting, leaves room for more

[2] We use a per unit tariff for the easier graphical exposition. An analysis with an ad valorem tariff produces qualitatively similar results.

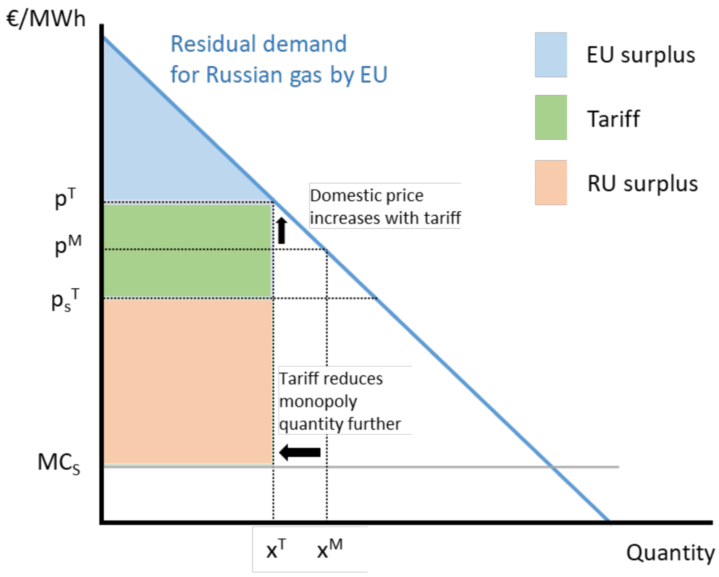

Figure 2: Tariff on Russian gas: Even lower quantities, and higher domestic prices.

efficient policy options, as we show in the following section.

4 A price cap on Russian gas

Now assume the EU would make use of its market power through acting as a single buyer creating the conditions of a monopsony and imposing a maximum price p^c, the price cap. Figure 3 shows such a setting where a price cap is imposed. Assuming the price cap policy is the EU's optimal strategy, credible and in Russia's best interest to comply with (Ehrhart and Schlecht 2022), the incentives for Russia in this setting are fundamentally different. Given the price it gets is fixed and no longer depends on the quantity that it supplies to the EU market, its economic incentive is to supply as much as possible to the EU as long as the price remains above its marginal cost. The outcome for the EU is also fundamentally different: It gets increased supply, resulting in a lower domestic price.

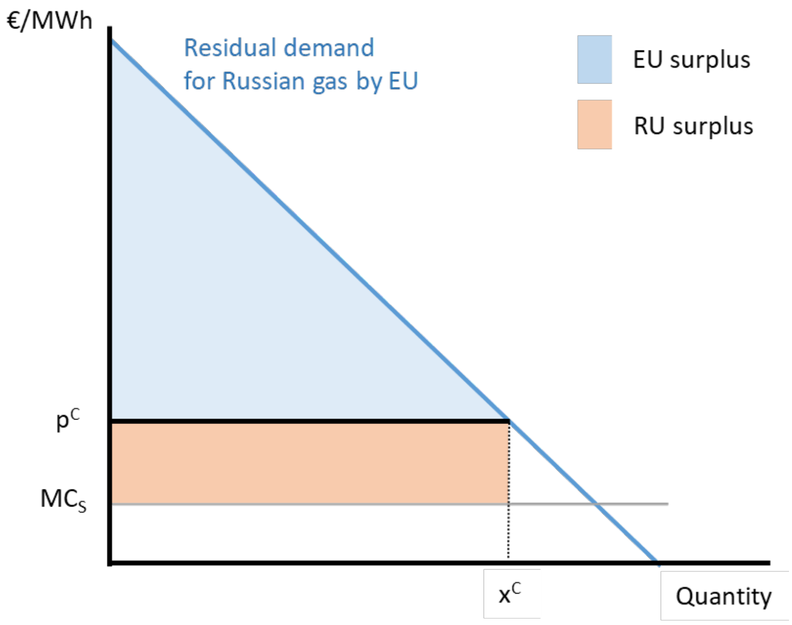

Figure 3: External price cap on Russian gas.

Looking at the welfare of both Russia and the EU, we can see that the EU welfare increases (the blue area in Figure 3 is larger than the one in the tariff case in Figure 2 even when including the EU tariff revenue), while Russian welfare decreases (at this specific price cap) to a similar level as with the tariff.

5 A price cap trumps a tariff in the case of EU-RU gas trade

Following from the above, we can conclude that in both cases, tariff and external price cap, EU welfare increases and Russian welfare decreases compared to the base case (Figure 1), but the EU welfare gains are larger in the case of a well-chosen price cap. The difference is that a tariff leads to reduced quantities and higher domestic gas prices for the EU, while a price cap leads to higher quantities and lower prices. In the case of a monopolistic price setting, where the demand side has market power that it can potentially exercise, a price cap is therefore advantageous over the introduction of a tariff.

In fact, it can be shown that 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 has the potential to exert market power itself, 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.[3]

[3]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 benefiting buyers by Russia. This is not

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. This can be easily shown by drawing the implications of the two policy instruments in one single graph (Figure 4).

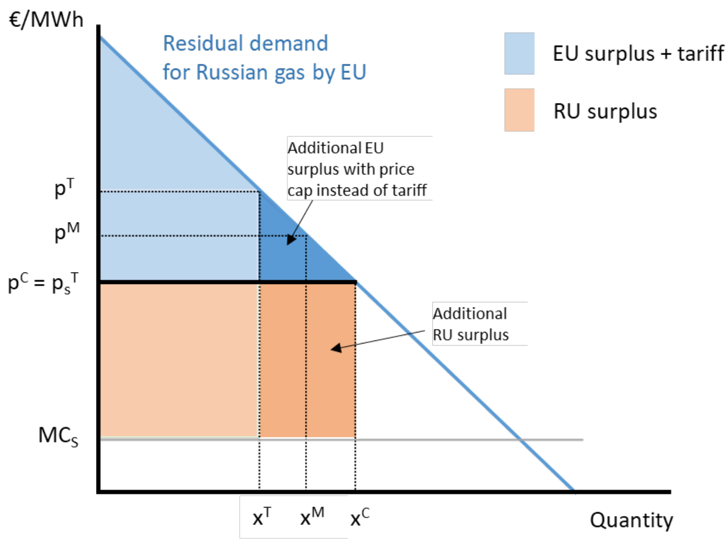

Figure 4: Demand and supply surplus in the tariff and price cap scenarios for $p^C = p_s^T$.

Figure 4 shows a comparison of the three scenarios monopoly (M), tariff in monopoly (T) and price cap (C). In terms of prices and quantities, there is a clear order in welfare terms for M and T. The monopoly price p^M is between the two prices under a tariff, the sales price for Russia p_s^T and the purchase price of the EU p^T, while the monopoly quantity x^M is higher than the quantity under a tariff x^T: $p_s^T < p^M < p^T$ and $x^T < x^M$. Setting the price cap to Russia's sales price, i.e. $p^C = p_s^T < p^M$, we can see that the highest quantity of the three scenarios occurs in the price cap scenario, i.e. $x^C > x^M$. In this case, the welfare of the EU and Russia is greater than under the tariff (including EU's tariff revenue). This can be seen in Figure 4 as the light blue and light orange areas under the tariff are extended by the blue and orange areas under the price cap. From Figure 4 also follows that a price cap at which the Russian producer surplus would be equal to Russian producer surplus under the tariff would be lower than p_s^T. This can be seen in Figure 5 with a lower price cap p^C where the Russian surplus (area of the light orange rectangle) is equal to the Russian surplus under the tariff (area of the light orange rectangle in Figure 4). As a result, the EU welfare is significantly larger in Figure 5 with a lower price cap than in Figure 4 with a

the case for an external price-cap on Russian gas implemented with the EU as a central buyer, since the EU holds a near-monopsony for Russian gas from the Western Siberian gas fields.

higher price cap (areas of the blue triangles). We prove the argument in a general formal model in the Appendix.

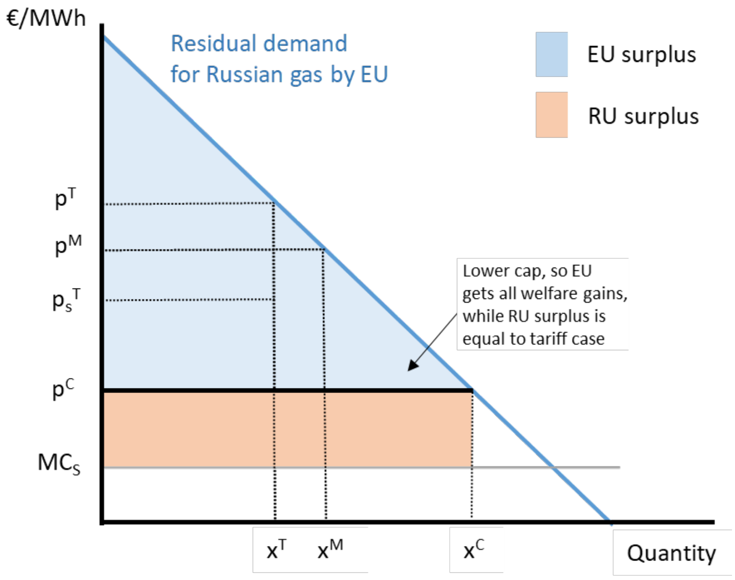

Figure 5: EU welfare improving price cap.

Note that these statements also hold in a more general context, since the above price and quantity orders also hold under more general assumptions about demand and cost functions.[4]

In the appendix, we show in a general formal model that for any tariff there exists a price cap that makes both the demand and the supply sides better off in the monopoly setting considered here. The argument only requires Russia to not have a completely inelastic elastic supply (Russia is reacting to prices) and the EU not to have a completely inelastic demand, but doesn't depend on the shape of EU demand (so long as it is downward sloping). The reason the shape of the EU demand function does not matter is that it does not matter how the initial price is set, so long as this price leads to a quantity below the market clearing quantity and a price above the market clearing price. Under a price cap p^C, which compared to a tariff achieves the same producer price p_s^T and which is smaller than the initial monopoly price, $p^C = p_s^T < p^M$:

- the monopolist is better off because they sell at the same price but higher quantity

[4]It has to be noted that in the case of a convex EU demand curve, there could be the possibility of the optimal tariff being 0, hence not changing the price and quantity compared to the case of Russian monopoly price setting and consequently EU and Russian welfare remain unchanged. Please see the Appendix for the formal analysis. This does not affect our main result of the dominance of a price cap vis-a-vis a tariff but only the relation of a tariff vis-a-vis the initial monopoly situation.

(since buyers face a lower price);

- households who were already buying see their price reduced from the monopolist's price plus the tariff to just the monopolist's price (this exactly offsets the loss in tariff revenue); and
- finally, households who were previously priced out by the tariff now also buy, so the EU is on the whole better off.

We therefore conclude that a successfully introduced price cap is generally superior to a tariff under the above assumptions of a monopolist market structure.

6 Conclusion and policy implications

Assuming economic rationale, both a tariff and a price cap can make the EU better off in the current situation of EU-Russia gas trade. However, we find that in the context of EU-Russia gas markets, given Russian economic calculus of a monopolist and potential EU monopsony market power, it can be shown that for any tariff there exists a price cap that makes both the demand and the supply sides better off compared to a corresponding tariff.

This is relevant for EU gas sanctions policy design, because assuming strategic interactions between the EU and Russia on the gas market (Ehrhart and Schlecht 2022), a price cap is the better policy instrument for the EU in such a stand-off, since for any threat the EU would make on the introduction of a tariff, the EU can propose a price cap that provides Russia with the same economic welfare (so it is equally likely to accept), but makes the EU better off in economic welfare terms.

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A Linear Model

Consider first a simple linear model where the demand function is given by $x(p) = \frac{a-p}{b}$ and the marginal costs of supply is constant, denoted by c.

Polypoly (*)

The competitive outcome in a polypoly market is:

$$\begin{aligned} p^* = c, \quad & x^* = \frac{a-c}{b}, \\ \pi_s^* = 0, \quad & \pi_d^* = \frac{(a-c)^2}{2b}, \end{aligned}$$

where π_s and π_d denote the welfare of the supplier and the welfare of the demand, which in this case equal the producer surplus and the consumer surplus, respectively.

Monopoly (M)

In a monopoly market, the calculation of the monopolist is

$$\max_p x(p)(p-c).$$

The first-order condition (FOC) is $x'(p)(p-c) + x(p) = 0$.

The outcome in the monopoly market is:

$$\begin{aligned} p^M &= \frac{a+c}{2}, \quad & x^M &= \frac{a-c}{2b}, \\ \pi_s^M &= \frac{(a-c)^2}{4b}, \quad & \pi_d^M &= \frac{(a-c)^2}{8b}. \end{aligned}$$

Given the solution above, the second-order derivative is $-\frac{2}{b} < 0$, so p^M maximizes the expected profit (and thus the welfare) of the monopolist.

Tariff (T)

If a percentage tariff t is levied on the supply price, denote the supply price by p_s, the demand price is $p = p_s(1+t)$. In this case, the calculation of the monopolist is

$$\max_{p_s} x(p)(p_s - c).$$

FOC: $x'(p)(1+t)(p_s - c) + x(p) = 0$.

Outcome:

$$
\begin{aligned}
p_s^T &= \frac{a+c(1+t)}{2(1+t)} \le p^M, \quad p^T = \frac{a+c(1+t)}{2} \ge p^M, \quad x^T = \frac{a-c(1+t)}{2b} \le x^M, \\
\pi_s^T &= x(p^T)(p_s^T - c) = \frac{(a-c(1+t))^2}{4b(1+t)} \le \pi_s^M, \\
\pi_d^T &= \frac{1}{2}x(p^T)(a-p^T) + x(p^T)(p^T - p_s^T) = \frac{(a-c(1+t))^2}{8b} + \frac{a^2-c^2(1+t)^2}{4b(1+t)}t,
\end{aligned}
$$

where the welfare of the demand is the sum of the consumer surplus and the tariff revenue. Given the solution above, the second-order derivative is $-\frac{t+2}{b} < 0$, so p_s^T and p^T maximize the expected profit of the monopolist.

Besides, it holds that

$$
\frac{\partial \pi_d^T}{\partial t} = \frac{a^2 - ac(1+t)^2 - c^2 t(1+t)^2}{4b(1+t)^2} \quad \Rightarrow \quad \frac{\partial \pi_d^T(t=0)}{\partial t} = \frac{a(a-c)}{4b} > 0.
$$

Therefore, there exists a optimal $t > 0$ for the demand.

Price cap (C)

If a price cap p^C with $p^C < p^M$ is imposed, the producer and consumer surplus (which equal their welfare) are

$$
\pi_s^C = x(p^C)(p^C - c), \quad \pi_d^C = \frac{1}{2}x(p^C)(a - p^C).
$$

Set $p^C = p_s^T$, there are

$$
\begin{aligned}
\pi_s^C &= x(p_s^T)(p_s^T - c) \ge \pi_s^T, \\
\pi_d^C &= \frac{1}{2}x(p_s^T)(a - p_s^T) \ge \pi_d^T.
\end{aligned}
$$

so both the consumer and the producer profit from the price cap (see Figure 4).

The optimal p^C, that maximizes the welfare of the demand under the assumption that the welfare of the supplier remains the same as with tariff (see Figure 5), can be calculated as follows:

$$
p^{C*} = \frac{(a+c)(1+t) - \sqrt{(a^2 - c^2(1+t))t(1+t)}}{2(1+t)} < p_s^T.
$$

B General model

Consider now a general model where the demand function $x(p)$ with $x'(p) < 0$ and $x(0) < \infty$ is not given explicitly. Besides, define the inverse function of $x(p)$ as $p(x)$. Assume again that $c = \text{const}$.

Monopoly (M)

The calculation of the monopolist remains the same:

$$\max_p \; x(p)(p-c).$$

FOC: $x'(p)(p-c) + x(p) = 0$.
Solution:

$$p^M = c + \frac{x(p^M)}{-x'(p^M)} > c \quad \text{and } x^M = x(p^M).$$

The producer and consumer surplus are

$$\begin{aligned}\pi_s^M &= x^M(p^M - c),\\ \pi_d^M &= \int_0^{x^M} p(y)dy - p^M x^M.\end{aligned}$$

It holds that $\pi_s'(p^M) = x'(p^M)(p^M - c) + x(p^M) = 0$, $\pi_s'(c) = x(c) > 0$ and $\pi_s'(p^M + \Delta) < 0$, where Δ is an arbitrarily small positive number, since the demand is finite, the solution above constitutes a maximum. As $x'(p^M) = \frac{x(p^M+\Delta)-x(p^M)}{\Delta}$, $\Delta \to 0^+$, the latter inequation can be shown as follows:

$$\begin{aligned}\pi_s'(p^M + \Delta) =& x'(p^M + \Delta)(p^M + \Delta - c) + x(p^M + \Delta)\\ =& x'(p^M)(p^M - c) + \Delta x'(p^M) + \Delta x'(p^M) + x(p^M)\\ =& 2\Delta x'(p^M) < 0.\end{aligned}$$

Tariff (T)

Assume again that the demand price is the supply price muliplied with $(1+t)$: $p = (1+t)p_s$ with $t > 0$. The calculation of the monopolist is

$$\max_{p_s} \; x((1+t)p_s)(p_s - c).$$

FOC: $(1+t)x'((1+t)p_s)(p_s - c) + x((1+t)p_s) = 0$.
Solution:

$$\begin{aligned} p_s^T &= c + \frac{x((1+t)p_s^T)}{-(1+t)x'((1+t)p_s^T)} > c, \\ p^T &= (1+t)p_s^T = (1+t)c + \frac{x(p^T)}{-x'(p^T)} > p_s^T. \end{aligned}$$

Similarly, it holds that $\pi_s'(p_s^T) = (1+t)x'((1+t)p_s^T)(p_s^T - c) + x((1+t)p_s^T) = 0$, $\pi_s'(c) = x((1+t)c) > 0$ and $\pi_s'(p_s^T + \frac{\Delta}{1+t}) = 2\Delta x'(p^T) < 0$, where Δ is an arbitrarily small positive number, so p_s^T maximizes the monopolist's profit.

Set p^T in the first order derivative in the monopoly case, we have

$$x'(p^T)(p^T - c) + x(p^T) = tcx'(p^T) < 0 \ \Rightarrow p^T > p^M.$$

Thus, the corresponding quantity $x^T = x(p^T)$ is less than x^M. Besides, it holds that

$$\begin{aligned} \pi_s''(p_s^T) &= (1+t)^2 x''((1+t)p_s^T)(p_s^T - c) + 2(1+t)x'((1+t)p_s^T), \\ \frac{\partial \pi_s'(p_s^T)}{\partial t} &= x'((1+t)p_s^T)(2p_s^T - c) + (1+t)p_s^T x''((1+t)p_s^T)(p_s^T - c). \end{aligned}$$

Since the FOC must be fulfilled, i.e., $\pi_s'(p_s^T) = 0$, the FOC can be represented as an implicit function $I(p_s^T, t) = \pi_s'(p_s^T) = 0$ in order to examine the relationship between p_s^T and t at the optimum. According to the implicit function theorem, we have

$$\frac{dp_s^T}{dt} = -\frac{\frac{\partial I(p_s^T,t)}{\partial t}}{\frac{\partial I(p_s^T,t)}{\partial p_s^T}} = -\frac{\frac{\partial \pi_s'(p_s^T)}{\partial t}}{\pi_s''(p_s^T)} = -\frac{p_s^T}{1+t} \frac{x'((1+t)p_s^T)(2p_s^T - c) + (1+t)p_s^T x''((1+t)p_s^T)(p_s^T - c)}{2p_s^T x'((1+t)p_s^T) + (1+t)p_s^T x''((1+t)p_s^T)(p_s^T - c)}.$$

As p_s^T maximizes π_s, it must apply that

$$\begin{aligned} &\pi_s''(p_s^T) = (1+t)^2 x''((1+t)p_s^T)(p_s^T - c) + 2(1+t)x'((1+t)p_s^T) < 0 \\ \Leftrightarrow\ & \frac{x''((1+t)p_s^T)}{-x'((1+t)p_s^T)} < \frac{2}{(1+t)(p_s^T - c)}. \end{aligned} \tag{1}$$

The condition in (1) is only a necessary but not a sufficient condition for $\frac{dp_s^T}{dt} < 0$. If

$$\frac{2 - \frac{c}{p_s^T}}{(1+t)(p_s^T - c)} \leq \frac{x''((1+t)p_s^T)}{-x'((1+t)p_s^T)} < \frac{2}{(1+t)(p_s^T - c)},$$

we have $\frac{dp_s^T}{dt} \geq 0$. That means $p_s^T > p^M$ and thus, the tariff reduces the consumer welfare.

For a negative $x''((1+t)p_s^T)$ or in general if the following condition is fulfilled,

$$\frac{x''((1+t)p_s^T)}{-x'((1+t)p_s^T)} < \frac{2-\frac{c}{p_s^T}}{(1+t)(p_s^T-c)}, \tag{2}$$

it applies that $\frac{dp_s^T}{dt} < 0$, that is, p_s^T is decreasing in t. Since $p_s^T(t=0) = p^M$, given a positive t, $p_s^T < p^M$. In this case, the welfare are

$$\begin{aligned}
\pi_s^T &= x^T(p_s^T - c) < \pi_s^M, \\
\pi_d^T &= \int_0^{x^T} p(y)dy - p_s^T x^T = \int_0^{x(p^T)} p(y)dy - p_s^T x(p^T).
\end{aligned}$$

Furthermore, it holds that

$$\begin{aligned}
&\frac{\partial \pi_d^T}{\partial t} = p^T x'(p^T)\frac{\partial p^T}{\partial t} - p_s^T x'(p^T)\frac{\partial p^T}{\partial t} - \frac{dp_s^T}{dt}x^T = tx'(p^T)\frac{\partial p^T}{\partial t} - \frac{dp_s^T}{dt}x^T \\
\Rightarrow &\frac{\partial \pi_d^T}{\partial t}(t=0) = -\frac{dp_s^T}{dt}x^T > 0.
\end{aligned}$$

Therefore, there exists $t > 0$ that makes the demand side better off than without tariff.

Price cap (C)

Impose price cap p^C. Set $p^C = p_s^T$, there is $x^C = x(p_s^T) > x(p^T) = x^T$. The welfare are

$$\begin{aligned}
\pi_s^C &= x^C(p^C - c) = x^C(p_s^T - c) > \pi_s^T, \\
\pi_d^C &= \int_0^{x^C} p(y)dy - p^C x^C = \pi_d^T + \int_{x^T}^{x^C} p(y)dy - p^C x^C + p_s^T x^T > \pi_d^T,
\end{aligned}$$

since for all $y \in [x^T, x^C]$, $p(y) \geq p(x^C) = p^C = p_s^T$.

Moreover, consider the price cap $\underline{p}^C < p_s^T$ which fulfills the following condition

$$\underline{\pi}_s^C = \pi_s^T \;\Leftrightarrow\; x(\underline{p}^C)(\underline{p}^C - c) = x^T(p_s^T - c).$$

As $\underline{x}^C = x(\underline{p}^C) > x(p_s^T) = x^C > x^T$, it applies that

$$\underline{\pi}_d^C = \int_0^{\underline{x}^C} p(y)dy - \underline{p}^C \underline{x}^C = \pi_d^C + \int_{x^C}^{\underline{x}^C} p(y)dy - \underline{p}^C \underline{x}^C + p^C x^C > \pi_d^C.$$

In conclusion, $\exists \underline{p}^C < p_s^T \;:\; \underline{\pi}_s^C = \pi_s^T < \pi_s^C$ for $\underline{x}^C > x^C > x^T$, and $\underline{\pi}_d^C > \pi_d^C > \pi_d^T$. That is, for any tariff there exists a price cap that makes both the demand and the supply sides better off. Note that the reverse case does not apply. More specifically, for any price cap $p^C \geq c$, there is no tariff t that better serves both the demand and supply sides.

Note that the statements above are independent of the condition in (2). If the condition in (2) is not satisfied, then $p_s^T > p^M$, $\underline{p}^C$ could be very high. In any case, it is not worth to set a price cap higher than p^M.