A MINIMALIST MODEL FOR THE RUBLE DURING THE RUSSIAN INVASION
OF UKRAINE

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## ABSTRACT

This note isolates an overlooked economic force for the Ruble to appreciate in response to international sanctions limiting exports to Russia. The economic intuition is that when Russians are unable to buy the mix of foreign goods they wish, then foreign goods becomes less attractive, increasing the demand for domestic goods; to reestablish an equilibrium a real appreciation is needed to raise the relative price of domestic goods and incentivizing the accumulation of foreign assets and the import from non-sanctioning countries. We also review well-known forces for a depreciation (e.g. Russian export reduction). Our analysis emphasizes that the exchange rate is an inadequate signal of welfare impacts and the effectiveness of sanctions.

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This note isolates an overlooked economic force for the Ruble to appreciate in response to international sanctions limiting exports to Russia. The economic intuition is that when Russians are unable to buy the mix of foreign goods they wish, then foreign goods becomes less attractive, increasing the demand for domestic goods; to reestablish an equilibrium a real appreciation is needed to raise the relative price of domestic goods and incentivizing the accumulation of foreign assets and the import from non-sanctioning countries. We also review well-known forces for a depreciation (e.g. Russian export reduction). Our analysis emphasizes that the exchange rate is an inadequate signal of welfare impacts and the effectiveness of sanctions.

# 1   Introduction

In light of the invasion by Russia of Ukraine and the economic sanctions taken and underway, there are many forces for a depreciation of the ruble (increased inflation, increase in foreign interest rates to Russia, capital flight etc.) The main purpose here is to spell out one overlooked force that pushes in the direction of an appreciation. We will also review the forces for depreciation, but those are more widely understood.

Maximizing realism is not our objective here; isolating one feature that may be important is. Thus, we present the simplest possible model: a representative agent, static one-period, endowments, small open economy, with competitive markets and flexible prices. However, the mechanisms for appreciation we isolate here would be present in other more elaborate models.

The basic idea is simple. All other things the same, sanctions that ration exports from the West to Russia create a force for appreciation. Because of the rationing, Russians are not able to buy the mix of foreign goods they wish; instead, they find themselves having

to either make additional purchases from countries that have not sanctioned Russia or to increase their saving in foreign assets. This is less desirable, and at the same relative prices Russians would try to instead increase their consumption of domestic goods. In equilibrium this must raise the relative price of domestic goods, that is, lead to a real appreciation.

An immediate corollary of this result, is that movements in the exchange rate are a poor measure of the welfare effect of sanctions. A country can be hurt both by restricting its ability to buy foreign goods and assets, and by restricting its ability to sell goods and assets to the rest of the world. Both restrictions hurt welfare. Movements in the exchange rate reflect the relative tightness of buying vs selling restrictions, not their absolute level.

## 2    Minimalist Model

Russian consumers have the utility function

$$u_{NT}(c_{NT}) + u_W(c_W) + u_O(c_O)$$

where $c_{NT}$ is not-tradable goods, $c_W$ is current imports from the EU and the US (who will impose sanctions), and $c_O$ is consumption of all other foreign goods (without sanctions).

There are two interpretation for the other import goods $c_O$. First, these could represent current goods from countries that do not sanction Russia, such as goods from China. Second, there is an intertemporal interpretation: the goods $c_O$ can represent indirectly the purchases of Western goods in the future, when sanctions will be lifted, by accumulating non-sanctioned assets. Indeed, we can interpret $u_C(c_O)$ as an indirect utility function incorporating both forms of consumption from non-sanctioning countries.[1] Similarly, $c_W$ and $c_{NT}$ have both a current and an intertemporal interpretation, with $c_W$ reflecting both current purchases of goods from the West and purchases of assets in the West that yield future flows of goods and services (e.g., euro deposits in foreign banks).

Russian consumers face the budget constraint

$$P_{NT}c_{NT} + S_R(p_W^* c_W + p_O^* c_O) = P_{NT}y_{NT} + S_R p_X^* y_X$$

where $P_{NT}$ is the price in rubles of domestic non-tradable goods (e.g. services); $S_R$ is the ruble exchange rate (rubles per dollar); $p_W^*$ is the price of western goods in dollars; $p_O^*$ is the price of other goods expressed in dollars today; $y_{NT}$ is the endowment/output of non-traded goods; $y_X$ is the endowment/output of the export good.

We take international prices as given and abstract from market power in international markets. It will also be convenient to assume exports are commodities that are not internally consumed nor consumable in Russia.

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[1]For example, $u_O(c_O) = \max_{c_C, c_+} \{u_C(c_O) + \beta u_W(c_+)\}$ subject to $p_C^* c_C + \frac{1}{R^*} p_+ c_+$ where $c_C$ represents current consumption from non-sanctioning countries and $c_+$ represents future consumption.

## 2.1 Equilibrium Conditions

The equilibrium conditions are as follows. First, we have the domestic market clearing condition

$$c_{NT} = y_{NT},$$

which, given the consumer budget constraint, is equivalent to the trade balance condition

$$p_W^* c_W + p_O^* c_O = p_X^* y_X. \tag{1}$$

Second, we have optimality conditions that equate the marginal rate of substitution between goods $O$ and $NT$ and their and relative price,

$$\frac{u_C'(c_O)}{u_{NT}'(y_{NT})} = \frac{S_R p_O^*}{P_{NT}}.$$

When there are no sanctions, an analogous condition holds for goods $W$ and $NT$,

$$\frac{u_W'(c_W)}{u_{NT}'(y_{NT})} = \frac{S_R p_W^*}{P_{NT}}.$$

However, when sanctions are in place, we will assume rationing and this condition no longer holds.

# 3 Import Rationing

We analyze the imposition of sanctions as a comparative static exercise. To isolate the forces for an appreciation we assume:

1. The imposition of sanctions by the West takes the form of quantity controls: the West simply impose a fixed cap on the ability of Russian consumers to purchase $c_W$. For simplicity, we assume it goes all the way to setting $c_W = 0$ by prohibiting exports to Russia. Note that we could do something less extreme here, the important assumption is that spending on western goods is forced to fall.

2. The exports of Russia are not significantly affected and, as an approximation we assume their revenue is not impacted at all, so that $p_X^* y_X$ is unchanged.

3. The price of other foreign goods $p_O^*$ is unchanged.

4. We also assume that the domestic economy is unaffected so that $y_{NT}$ is unchanged.

5. The Central Bank of Russia ensures that $P_{NT}$ is not affected.

Again, these assumptions are not meant to be taken literally. Some are perhaps realistic as approximations, but mostly they are motivated to help isolate the particular effect and mechanism we are after. The last condition is not required, but facilitates the discussion. Without it we could determine the real exchange rate in the same way we will determine the nominal exchange rate.

We now derive the main result; we then discuss other cases, some providing forces for a depreciation. Let primes denote variables after the imposition of the quantity controls. The trade balance condition (1) immediately implies that consumption of other foreign goods rises $c'_O > c_O$. In the marginal condition

$$\frac{u'_C(c'_O)}{u'_{NT}(y_{NT})} = \frac{S'_R p^*_O}{P_{NT}},$$

(2)

the marginal utility of the other goods $u'_C(c'_O)$ must then be decreasing. Since $y_{NT}$ is fixed, and $p^*_O$ and $P_{NT}$ are also unaffected, it follows that the exchange rate must appreciate: $S'_R < S_R$.

The math has the following economic intuition. The ruble appreciates because Russian consumers are not able to buy the mix of foreign goods they wish. This makes buying foreign goods less attractive. It is as if Russians had suffered a negative shock to their desire for foreign goods or a positive demand shock for domestic goods. As a result, in equilibrium domestic goods must become more expensive relative to the available foreign goods. As domestic goods (in rubles) and foreign prices (in foreign currency) are held constant, this change in relative prices is obtained by a ruble appreciation.

From a currency market point of view, the flow demand for rubles rises, since Russians are less interested in buying other foreign goods. The foreign exchange is a medium for this, so it suffers relative to the ruble.

A few comments are in order.

1. If we allow $P_{NT}$ to rise, then the conclusion still follows for the real exchange rate, so the prediction is that $S_R / P_{NT}$ falls.

2. If sanctions make domestic export revenue $p^*_X y_X$ fall, then this is a force for $\frac{u'_C(c'_O)}{u'_{NT}(y_{NT})}$ to rise and for $S_R$ to rise (depreciate). Indeed, a significant fall in export revenue is possible if Russian gas and oil exports are embargoed.[2] This could lower $y_X$ and $p^*_X$. A drop in domestic output may also result from the sanctions producing a domestic economic and financial crises in Russia, which will have repercussions to domestic output. In the short run, however, stockpiling goods and spending to avoid an inflation tax may boost domestic output.

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[2]See Bachmann et al. (2022) for an analysis on the costs to Germany of such an embargo.

3. On the other hand, an increase in energy prices implies an increase in $p_X^* y_X$ and, all else equal, is an additional force for appreciation, through a positive wealth effect, different from the one emphasized here. Unlike the appreciation forces emphasized here, this is a force for appreciation that does map into higher welfare for Russian consumers.

4. It is possible that even if $p_X^* y_X$ does not fall, that the flow revenue from exports is partly or fully frozen so that it cannot be used for spending on imports of any kind; it is also possible that the Russian State increasingly uses the revenue to import military goods that do not enter the utility function. From the point of view of the model laid out here, this is simile to a decline in current exports $p_X^* y_X$. These considerations would also go in the opposite direction of the forces described here push in the direction of a currency depreciation.

5. Somewhat less directly, if the sanctions cause domestic output $y_{NT}$ to fall then there is another force for appreciation; can sanctions make domestic output of non-traded goods fall? Potentially yes, although this is less clear; output could be affected if some essential inputs that are imported become unavailable; however, for non-traded goods like services this is unlikely. Disruptions from lower demand could also occur if there is a crises leading to a recession that monetary and fiscal policy cannot offset.

   The reverse, a rise in non-traded goods $y_{NT}$ due to sanctions, is not impossible, however: if export production drops and the labor released can reallocate to non-traded goods; this is unlikely to play a role in the short run.

6. The additive separability of preferences plays some role in the analysis, but the results hold more generally as long as the decrease in $c_W$ does not increase the marginal utility of $c_O$ too much. Consider the limit case in which $O$ and $W$ are perfect substitutes, so the utility function is $u_{NT}(c_{NT}) + u^*(c_W + c_O)$. In that case, the exchange rate (and everything else!) would be completely unaffected by the drop in $c_W$.

7. Rationing of imports $c_W$ plays a role. In the next section we discuss the case where the reduction in $c_W$ is achieved not by rationing but by a tax. Note that we can define the shadow or black market price of good $W$ *inside* Russia

$$\tilde{p}_W^* = \frac{P_{NT}}{S_R} \frac{u_W'(c_W)}{u_{NT}'(y_{NT})}.$$

   The quantity control lowers $c_W$ and raises $\tilde{p}_W^*$. Importantly, this price is not the price that enters the trade balance condition. Instead, the rationed Russians who still can purchase $W$ continue to pay $p_W^*$ that enters these conditions, ensuring that $c_O$ always rises.[3]

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[3]In our baseline, we lower $c_W$ to zero and so $\tilde{p}_W^* = \frac{P_{NT}}{S_R} \frac{u_W'(0)}{u_{NT}'(y_{NT})}$ is possibly infinite if $u'(0) = \infty$. More generally the price rises, but to a finite and lower level.

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These points clarify that there are standard forces for depreciation if domestic output or exports are affected. These forces must be netted against the force for appreciation isolated here.

# 4   Other Types of Import Restrictions

We now briefly discuss other possible form of sanctions that can reduce exports from the West to Russia.

## 4.1   Import Sanctions without Rationing

Suppose the West imposes a tax on exports to Russia. As Russia is a small open economy in our model, the incidence of the tax falls fully on the Russian consumers, so the tax is equivalent to an increase in the price $p_W^*$ that Russians pay for good $W$. This could occur if the west imposed taxes on exports to Russia, similar to the analysis in Sturm (2022) and the policy proposal by Hausmann (2022), but with a focus on Russian imports rather than exports.

A rise in $p_W^*$ could also capture a situation where some exports to Russia are completely shut down for some goods from the West while other goods are maintained at the same price. Then taken as a whole, the price index of western goods $p_W^*$ would rise.[4]

An appreciation is still possible, but it depends on whether $p_W^* c_W$ rises or falls when $p_W^*$ increases. If this is the case, all the previous analysis goes through, since this increases $c_O$. Expenditure may rise or fall depending on whether the demand for $W$ has own-price elasticity greater or less than 1. Equivalently, an appreciation occurs as long as $c_O$ is a Marshallian substitute, rather than a complement. This is determined by the shape of $u_W$ and $u_C$ as follows.

Define the demands $c_W(p_W^*, p_O^*, e^*)$ and $c_O(p_W^*, p_O^*, e^*)$ from

$$\max_{c_W, c_O}[u_W(c_W) + u_O(c_O)] \qquad \text{s.t.} \qquad p_W^* c_W + p_O^* c_O = e^*$$

for any expenditure $e^*$. Then a foreign-imposed tax on Russian imports leads to an appreciation of the ruble if the function $p_W^* c_W(p_W^*, p_O^*, e^*)$ is decreasing in $p_W^*$, or, equivalently, if $c_O(p_W^*, p_O^*, e^*)$ is increasing in $p_W^*$. As an example if $u_W(c) = u_O(c) = c^{1-1/\rho}/(1-1/\rho)$ the result holds if the elasticity of substitution satisfies $\rho > 1$. The Cobb-Douglas case $\rho = 1$ is the borderline case where $c_O$ is unchanged.

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[4]To see this, suppose $c_W = \left(\int c_W(i)^{1-\frac{1}{\epsilon}} di\right)^{\frac{1}{1-\frac{1}{\epsilon}}}$ where $\epsilon > 1$ is the elasticity across a variety of western goods $i \in [0,1]$ with price $p_W(i)$. The price index is $p_W^* = (\int p_W(i)^{1-\epsilon} di)^{\frac{1}{1-\epsilon}}$. If some fraction $\omega$ of goods remains available at the old price $p_W^*(i)$ and all other varieties are made unavailable, so $p_W^*(i) = \infty$ for them, then the new price index of the import basket is $\omega^{\frac{1}{1-\epsilon}} p_W^* > p_W^*$.

## 4.2 Prospective asset freezes

As mentioned above, there is an intertemporal interpretation of our model, where purchases of good $W$ represent purchases of assets in the West by Russian nationals, that produce a future flow of benefits. Under this interpretation, another way of thinking about sanctions on exports is to think of restrictions that limit the ability of Russian asset holders to extract benefits from their assets abroad, either for fear of future freezes/seizures that reduce the value or liquidity of the assets, or other forms of stigma that reduce the enjoyment of those assets. These restrictions can be captured by writing the Russian consumer problem as maximizing utility subject to

$$P_{NT}c_{NT} + S_R(p_W^* \frac{c_W}{1-\delta} + p_O^* c_O) = P_{NT}y_{NT} + S_R p_X^* y_X$$

where $\delta$ is the fraction of the asset payoff that is lost due to sanctioning. Notice that the analysis of the consumer problem is formally equivalent to the case of a tax, since the effective price is now

$$\frac{p_W^*}{1-\delta} > p_W^*.$$

So again, whether these restrictions lead to an appreciation depends on elasticities, exactly as in the analysis above.

It is useful to add a clarifying remark on the overall effect of restrictions on assets held abroad. The *realized* freezing of dollar accounts of some domestic entities can be captured in our model as equivalent to a reduction of the endowment of tradables $p_X^* y_X$. This is a wealth effect and is, *per se*, a force for depreciation, as it reduces the spending capacity of the country on international goods (reducing $c_W$ and $c_O$, while keeping $c_{NT}$ unchanged). However, the *prospective* freezing of foreign assets accumulated today acts as an opposing force, as it reduces the marginal incentive to accumulate foreign assets, by reducing the country's ability to turn its tradable resources into future flows of foreign goods and services. This second force is the one captured by the loss $\delta$ above, and is, a possible force for appreciation.

# 5 Evading Sanctions

What if some consumers are able to circumvent the sanctions? Does this create a black market for foreign currency and what happens in that market?

When restrictions are imposed on asset and/or goods trades, it is always possible that some agents can legally or illegaly evade those restrictions. When these agents trade currency among each other, it can possibly create a black market where the currency is traded at a price different from the official market.

Consider first just the behavior of an individual agent who can evade the sanctions and have free access to good $W$. The agent is small, so his behavior does not affect the equilibrium studied above. The agent will maximize utility subject to the pre-sanction budget constraint, but at the new, appreciated exchange rate $S'_R$,

$$P_{NT}c_{NT} + S'_R(p_W^* c_W + p_O^* c_O) = P_{NT}y_{NT} + S'_R p_X^* y_X.$$

This agent would then choose a consumption basket $\hat{c}_W, \hat{c}_O, \hat{c}_{NT}$ different from the representative agent, with less non-tradable goods, $\hat{c}_{NT} < y_{NT}$, less non-sanctioned tradables $O$, $\hat{c}_O < c_O$, and, of course, more sanctioned tradables $W$, $\hat{c}_W > 0$. These results come straight from the optimality conditions

$$\frac{u'_C(\hat{c}_W)}{u'_{NT}(\hat{c}_{NT})} = \frac{S'_R p_W^*}{P_{NT}}, \frac{u'_C(\hat{c}_C)}{u'_{NT}(\hat{c}_{NT})} = \frac{S'_R p_C^*}{P_{NT}}.$$

Consider next what happens if there is a positive mass of agents who can evade sanctions. That will change the equilibrium exchange rate $S'_R$, by allowing the fully sanctioned agents to expand their consumption of $NT$ goods and not just their consumption of $C$ goods, thus increasing the marginal rate of substitution on the left-hand side of (2). So if some agents can evade sanctions it dampens the appreciating force, but it's not enough per se to create a black market for currency.

A black market arises if fully sanctioned agents are somehow restricted from trading with agents who can avoid the sanctions. A specific example is a foreign firm who can trade rubles per dollars and then transfers the dollars abroad and use them with no restriction. Here again we can think of $W$ as assets in the West and $NT$ as productive assets or real estate in Russia: the foreign firm sells Russian assets and gets out. This increases the supply of $NT$ for the agents in the country, as in the analysis above, and dampens the appreciation. However, if the foreign firm is not allowed to freely trade currency with Russian nationals, then a black market will arise. In other words, the sanctions we examined here are not enough, per se, to create a black market, but, in combination with other restrictions, like capital controls, they do.

## 6 Conclusion

Two final thoughts.

First, the fact that the Ruble may appreciate does not imply that sanctions do not work, or do not have their intended effect. These punitive measures do reduce welfare in Russia. Indeed, in our baseline example the fact the currency appreciates is a sign that the sanctions are working. In that example, welfare falls, but the exchange rate appreciates. Moreover, if the Russian State owns part of the revenue from exports, directly or indirectly through taxation or leasing, but spends disproportionally on domestic goods (e.g.

salaries), then its public finances are hurt by an appreciation and instead aided by a depreciation.

Second, our analysis shows that a focus on the exchange rate may be misplaced. Indeed, eventually the exchange rate may not be as interesting a price under extreme sanctions; as intratemporal and intertemporal trade is shut down, it just becomes a less important relative price. To take the extreme, in the limit case of enforced autarky, the exchange rate ceases to have any relevance.

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