

Sanctions and the Exchange Rate

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Trade wars and financial sanctions are again becoming an increasingly common part of the international economic landscape, and the dynamics of the exchange rate are often used in real time to evaluate the effectiveness of sanctions and policy responses. We show that sanctions limiting a country's exports or freezing its assets depreciate the exchange rate, while sanctions limiting imports appreciate it, even when both types of policies have exactly the same effect on real allocations, including household welfare and government fiscal revenues. Beyond the direct effect from sanctions, increased precautionary savings in foreign currency also depreciate the exchange rate when they are not offset by the sale of official reserves or financial repression of foreign-currency savings. We show that the dynamics of the ruble exchange rate following Russia's invasion of Ukraine in February 2022 are quantitatively consistent with the combined effects of these forces calibrated to the observed sanctions and government policies. We evaluate the associated welfare, fiscal and inflationary consequences for both Russia and the coalition of Western countries.

Key words: Trade sanctions, Financial sanctions, Financial repression, FX market

JEL codes: E50, F31, F32, F41, F51

1. INTRODUCTION

Despite a period of liberalization following the end of the Cold War, tariffs, trade wars and financial sanctions have become frequent tools of international policymaking in the last 10 years. This renewal has led to an increased interest in the welfare and allocative consequences, and, more generally, the overall effectiveness of different forms of international economic and financial warfare, as well as the ability of affected countries to neutralize its effects with various domestic policies. The real effects of trade restrictions and financial sanctions are often difficult to evaluate in real time, and this is why the exchange rate—a variable that responds observably and swiftly to news and reflects the expected near-term and long-term consequences of policies—has received particular attention as a telltale for the economic impact of trade restrictions and sanctions.

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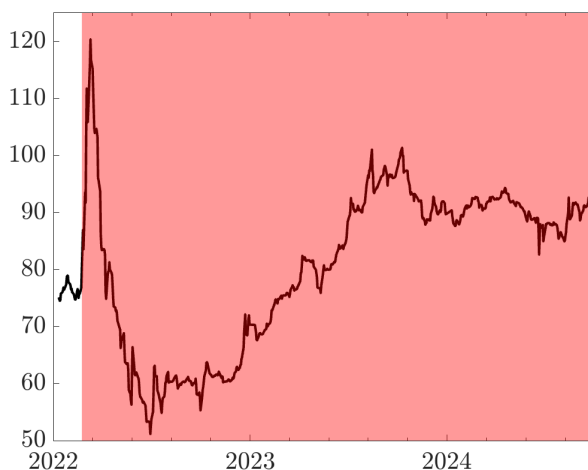


FIGURE 1

Daily ruble exchange rate (per one USD) since 1 January 2022

This paper is motivated, in particular, by the recent sequence of sanctions imposed by the coalition of Western countries on the Russian economy in response to Russia's invasion of Ukraine on 24 February 2022. In the immediate aftermath of the invasion and the imposition of sanctions, the Russian ruble quickly lost half of its value. However, the exchange rate recovered to its pre-war level a few weeks later, appreciated another 30% by June, and then gradually depreciated over the following year, stabilizing about 20% weaker relative to its pre-war level (see Figure 1). These dynamics pose a number of challenges for policy analysis. What explains these large swings in the exchange rate despite a monotonically increasing number of sanctions imposed on the Russian economy? Did a strong ruble in 2022 mean that initial sanctions were not working and had only minor effects on the Russian economy? Or, to the contrary, is the ruble exchange rate no longer relevant for economic allocations because of Russian-imposed capital controls and financial repression, as has been suggested by other commentators?¹ What are the fiscal implications, and can domestic policy curb the negative effects of international sanctions?

This paper offers a unifying framework to address these questions building on the model from Itskhoki and Mukhin (2021, 2025a) that has been shown to be consistent with the major properties of exchange rates in the data. In accordance with the decoupling of the Russian financial market from the global market, we assume a form of financial market segmentation in which only the government sector (including state banks and exporting companies) can intermediate capital flows across the border, subject to international restrictions.² This leaves exports and foreign exchange (FX) reserves as key sources of currency supply to the economy, and imports and domestic foreign-currency savings as key sources of currency demand. The equilibrium value of the exchange rate is determined by the balance of currency demand and supply in the domestic market, and depends crucially on shocks in both goods and asset markets. The model is tractable and attains a closed-form characterization, yet features a rich set of international sanctions and

1. See *e.g.* P. Krugman "Working Out: The Curious Case of the Recovering Ruble" (NYT, 1 April 2022), S. Guriev "The Incredible Bouncing Ruble" (Project Syndicate, April 12, 2022), and L. Garicano "Sanctions against Russia" (March 8, 2022).

2. This captures both the withdrawal of foreign investors from the Russian market and the segmentation of Russian households from the international financial market due to external sanctions and domestic capital controls.

domestic policy responses which allows us to perform a detailed quantitative analysis of the effects of a spectrum of sanctions on the exchange rate, welfare, budget deficit and inflation.

Our first main result shows that sanctions limiting imports of a country tend to appreciate the country's exchange rate, while sanctions limiting exports (and seizing foreign assets) tend to depreciate it, even though both policies have the same effect on real allocations and the resulting welfare. Intuitively, both kinds of sanctions reduce the real income of the economy – either by limiting the inflow of dollars or increasing the dollar prices of foreign goods – resulting in lower consumption of foreign goods. We show that this equivalence is a manifestation of [Lerner \(1936\)](#) symmetry, which postulates that export and import restrictions yield the same economic outcomes, but are sustained by a differential movement in relative prices.³ In our context, since export sanctions reduce the supply of foreign currency, they depreciate the country's exchange rate, and vice versa import sanctions reduce the demand for foreign currency and appreciate the country's exchange rate.

This observation clarifies several recently debated issues. First, it follows immediately that there is no one-to-one mapping between the exchange rate and welfare. Therefore, one cannot evaluate the effectiveness of sanctions based solely on the dynamics of the exchange rate. Second, while import and export restrictions have the same allocative effects, the effectiveness of each tool is limited if the sanctioned country can find alternative trade partners. In this case, it might be optimal to employ both types of sanctions as they have a cumulative effect.⁴ Third, perhaps most surprisingly, the equivalence result for export and import sanctions extends to the fiscal balance, even when the government relies exclusively on exports for fiscal revenues. This is achieved by means of a general equilibrium adjustment in the exchange rate. That is, a depreciation partially ameliorates the impact of export sanctions by increasing the local-currency purchasing power of export revenues, while import sanctions result in an exchange rate appreciation which has the opposite effect. The net fiscal-balance effect of both kinds of sanctions ends up being the same.

When the sanctioned economy is large, *e.g.* like Russia in the global commodity market, we show that import prices and export revenues still constitute a sufficient statistic for the macroeconomic effects on the economy under sanctions. At the same time, the welfare implications for the rest of the world depend crucially on whether sanctions take the form of trade taxes or quantity restrictions. In particular, both a tax imposed on the country's imports and a tax imposed on its exports ultimately reduce the country's terms of trade and transfer wealth to the rest of the world. Similarly, a price cap on exported commodities can replicate the effect of a tax on exports achieving the desired wealth transfer. In contrast, imposing quantity restrictions on a large commodity exporter reduces global supply and drives up world energy prices. While this still hurts the sanctioned economy when it lowers its export revenues, such policy is also associated with substantial costs to sender.

3. By Lerner symmetry, export (import) restrictions result in a reduction (increase) in the country's relative wages—a form of a *real* depreciation (appreciation)—in order to achieve intertemporal trade balance. The *terms of trade*, however, move in the same way for both cases: in particular, they deteriorate under foreign-imposed restrictions. Nonetheless, measuring the effective terms of trade is challenging because many trade sanctions take the form of quantity restrictions. This is the reason why most commentators focus on the easily observable exchange rate. For the recent macroeconomic analysis of Lerner symmetry in other contexts, see [Farhi et al. \(2014\)](#), [Barbiero et al. \(2019\)](#), [Costinot and Werning \(2019\)](#) and [Lindé and Pescatori \(2019\)](#). While trade applications of Lerner symmetry emphasize *uniform* tariffs across traded goods, *macroeconomic* symmetry emphasizes uniform shifts in aggregate terms of trade over time (see [Itskhoki and Mukhin, 2023a](#)).

4. Studying sanctions evasion and the substitution between trade partners is crucial for the optimal sanctions design, but goes beyond the scope of this paper (see [Egorov et al., 2024](#); [Chupilkin et al., 2024](#)).

Turning to financial sanctions, we show that their effects depend crucially on the policy response. In particular, an increase in the household precautionary demand for foreign currency due to a collapsing supply of alternative savings vehicles (*e.g.* local stock market, bank deposits) results in exchange rate depreciation in the absence of active government intervention. With financial restrictions on international borrowing and inelastic inflow of foreign currency from exports, a large jump-depreciation is required to restore the equilibrium by curbing the increased demand for foreign currency via lower expected returns and higher prices of imports. The effect of the financial shock is transitory and dies out as households accumulate enough foreign-currency savings. The optimal policy response to the financial shock aims to smooth out these dynamics by selling FX reserves to the households. This is a welfare enhancing intervention because it accommodates the increased household demand for foreign currency without an exchange rate devaluation or a drop in import consumption (see [Itskhoki and Mukhin, 2023b](#)). However, FX interventions rely on the availability of official reserves, and this policy may be altogether infeasible under international financial sanctions against the central bank.

When FX interventions are infeasible, the government can use financial repression to offset the effects of financial shocks on the exchange rate and import consumption, albeit with a distortion in the domestic financial market. Specifically, the central bank can reduce the household foreign-currency demand for savings by lowering the returns on foreign-currency deposits through fees on purchasing and withdrawing foreign currency.⁵ While financial repression is suboptimal in a representative-agent economy, it may emerge as a second-best policy to smooth out redistributive effects of exchange rate fluctuations in heterogenous-agent economies or economies with balance-sheet effects. Importantly, the exchange rate remains allocative even under financial sanctions and financial repression.

Finally, we quantitatively evaluate the ruble exchange rate dynamics since the beginning of the war by combining financial and trade sanctions and policy responses in a calibrated model. We use the standard values of import and savings demand elasticities and adopt two alternative strategies to calibrate the paths of shocks. The first one reproduces our *ex-ante* calibration from the 2022 version of the paper ([Itskhoki and Mukhin, 2022](#)) based on scant data that were available in the first months after the start of the war and without targeting any exchange rate moments. The calibration provides a remarkable out-of-sample fit, predicting accurately the dynamics of the exchange rate in the following 2 years. We then compare it with an *ex-post* calibration that infers structural shocks to perfectly match observed dynamics of Russian imports and exports, commodity prices, domestic output, official FX reserves, inflation and the exchange rate.

The two approaches largely agree on the decomposition of the exchange rate confirming the quantitative importance of theoretical mechanisms discussed above. In particular, we find that the sharp depreciation of the ruble in the first weeks of the war is mostly driven by increased precautionary demand for foreign currency. The large amount of FX reserves frozen by sanctions translates into modest losses of permanent income and generates only a 3% depreciation of the exchange rate. However, the asset freeze and sanctions on the Central Bank likely had a much larger indirect effect by limiting the capacity to accommodate the financial shock with FX interventions.

One month out, trade shocks begin to dominate the dynamics of the exchange rate. Restrictions on imports curb FX demand to purchase imported goods, while the spike in energy prices elevates Russian export revenues in the first months after the invasion, increasing the inflows of

5. Indeed, the Russian central bank introduced a temporary fee on buying foreign currency in March-April, which lowered the depreciatory pressure on the exchange rate.

foreign currency. These forces combined neutralize capital outflows and the surge in financial FX demand, and explain the sharp appreciation of the ruble by summer 2022. Over time, import quantities recover as parallel imports and new trade linkages are established, and the inflow of foreign currency contracts as commodity export revenues decline. This brings the exchange rate back to the pre-war level about one year after the start of the war with a continued gradual depreciation thereafter.

We further use the calibrated model to evaluate the impact of sanctions on the household welfare and the government budget balance, as well as implications for the sanctioning coalition. The initial depreciation of the exchange rate boosts fiscal revenues by 12% and this is further amplified by greater export revenues starting in the second month. These effects are offset in the medium run as a result of the exchange rate appreciation due to trade sanctions with the net real income turning negative starting from April 2022. The international sanctions decrease the long-run real government revenues by about 4%, mostly due to a reduction in export revenues. The combined effect from 2.5 years of sanctions also corresponds to a permanent decline in consumption by 0.9% in Russia, vastly larger than the conventional estimates of the cost of a business cycle, and it is close to zero on net for the rest of the world. Consistent with our theoretical results, the freeze of FX reserves and import tariffs act as a positive transfer from Russia to the rest of the world, while quantity restrictions on exports result in higher energy prices, lower consumption, and global welfare losses.

This paper contributes to the growing literature on the economic effects of sanctions. Korhonen (2019), Itskhoki and Ribakova (2024) and Mohr and Trebesch (2025) provide surveys of the earlier and recent work with particular focus on the Russian economy.⁶ The analysis of the effects of a Russian energy export ban on the European economy is the focus of Bachmann *et al.* (2024). Bianchi and Sosa-Padilla (2022), Sturm (2022), de Souza *et al.* (2022) and Alekseev and Lin (2024) study the design of optimal sanctions (see also the early work on the topic, *e.g.* Eaton and Engers, 1992), while Clayton *et al.* (2023) analyze strategic interactions between economies. Eichengreen *et al.* (2023) and Krahne *et al.* (2024) provide historical evidence about the effects of trade sanctions which validate the main predictions of our model.

Our theoretical results on trade sanctions are closely related to the contemporaneous work of Lorenzoni and Werning (2023). We show how to cast the analysis of static trade sanctions within a macroeconomic model, extending the seminal Lerner (1936) symmetry result to a fully dynamic environment. Furthermore, we go beyond Lerner symmetry to analytically and quantitatively study the implications of dynamic trade and financial sanctions for exchange rates, welfare, inflation and government revenues under alternative policy responses.

2. SMALL ECONOMY UNDER SANCTIONS

We start our analysis with the case of a small open endowment economy under trade and financial sanctions, where trade sanction are summarized by an exogenous deterioration of the country's terms of trade. In the following Section 3, we extend our analysis to an economy that is large in the world commodity market and consider various specific instruments of trade sanctions imposed by the rest of the world. We make one departure from a conventional international

6. For broader surveys of the earlier work on international sanctions see Eaton and Sykes (1998) and Hufbauer *et al.* (2009). A large parallel literature, summarized recently in Fajgelbaum and Khandelwal (2022), studies the economic effects of tariffs and trade wars. A related macroeconomic literature on sanctions, trade wars, currency wars and currency manipulations includes Svensson and Razin (1983), Auray *et al.* (2021), Jeanne (2021), Hassan *et al.* (2023), Mamonov and Pestova (2023) and Ghironi *et al.* (2022).

macro model in that the households are segmented from the international financial market and demand foreign currency to both purchase imports and as a store of value.⁷

2.1. The model economy

Households choose the path of consumption of domestic and imported goods C_{Ht} and C_{Ft} to maximize their intertemporal utility

$$U_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[u(C_{Ht}, C_{Ft}) + v \left(\frac{B_{t+1}^*}{P_{t+1}^*}; \Psi_t \right) \right], \quad (1)$$

subject to the household budget constraint

$$P_t C_{Ht} + \mathcal{E}_t P_t^* C_{Ft} + \frac{B_{t+1}}{R_t} + \frac{\mathcal{E}_t B_{t+1}^*}{R_{Ht}^*} \leq B_t + \mathcal{E}_t B_t^* + W_t, \quad (2)$$

where P_t and P_t^* are consumer prices of domestic and imported goods in the local and foreign currency, respectively, and W_t is the nominal income of the households. Asterisk * denotes variables denominated in foreign currency and the nominal exchange rate $\mathcal{E}_t$ is applied to convert them to local currency: $\mathcal{E}_t$ is defined as units of local currency for one unit of foreign currency and an increase in $\mathcal{E}_t$ corresponds to the local currency devaluation.

Households can save or borrow using local- and foreign-currency bonds, that is, bank deposits and loans. We denote with B_t and B_t^* the quantities of these bonds held by the households, and with R_t and R_{Ht}^* the respective gross interest rates. The return R_{Ht}^* on foreign-currency savings available to the households may differ from the international rate of return R_t^* due to household segmentation from the international asset market. Households are assumed to have the real value of foreign-currency deposits in their utility function reflecting hedging (precautionary) demand for future purchases of foreign tradables, and Ψ_t captures a shock to the demand for foreign-currency balances.⁸

While our theoretical results require only weak assumptions on the utility function, we adopt the following functional forms that we use in particular in our quantitative analysis:

$$u(C_H, C_F) = C_H^{\frac{\theta-1}{\theta}} + \gamma^{1/\theta} C_F^{\frac{\theta-1}{\theta}} \quad \text{and} \quad v(b; \Psi) = -\frac{\kappa}{2} \cdot (b - \Psi)^2, \quad (3)$$

where $\theta > 1$ is the elasticity of substitution between domestic and imported goods, $\gamma > 0$ is the exposure to imported goods (openness), and $\kappa \geq 0$ is the bond demand parameter.⁹ This

7. An alternative modelling approach features a frictional international intermediation sector as a source of inelastic foreign currency supply (as in [Gabaix and Maggiori, 2015](#); [Itskhoki and Mukhin, 2021](#)). Our modelling choice is motivated by both simplicity and realism in the case of Russia under international sanctions.

8. We use this simple setup with bonds in the utility to generate fundamental foreign currency demand shocks, as opposed to an alternative setup with noise currency traders (as in [Jeanne and Rose, 2002](#); [Itskhoki and Mukhin, 2021](#)). This makes our model directly amenable to the welfare and normative analysis of such policies as financial repression. The precautionary demand for safe assets also arises in a large class of models with incomplete markets ([Aiyagari, 1994](#)) and overlapping generations ([Diamond, 1965](#); [Blanchard, 1985](#); [Caballero et al., 2008](#)); see also the growing empirical literature on convenience yields ([Jiang et al., 2018](#); [Bianchi et al., 2021](#)). All our results still hold if real bond holdings are computed using the consumer price index $\mathcal{P}_t$, replacing B_t^*/P_t^* with $\mathcal{E}_t B_t^*/\mathcal{P}_t$ in the utility.

9. See the working paper version [Itskhoki and Mukhin \(2022\)](#) for the analysis under more general functional forms.

convenient separable utility specification implies that θ is also the intertemporal elasticity of substitution, and hence $1/\theta$ is relative risk aversion. The utility from FX bond holdings is increasing for $B_{t+1}^*/P_{t+1}^* < \Psi_t$ and has a bliss point at $B_{t+1}^*/P_{t+1}^* = \Psi_t$ for a given value of the shock Ψ_t .

Government, output, and financing. We combine the government, production and financial sectors into one entity. While being a useful abstraction, this approach is representative of the structure of the Russian economy, where the public sector accounts—directly and indirectly—for a major fraction of employment in both tradables and non-tradables (natural resources, transportation, healthcare and education), as well as in finance and banking. The budget constraint of the government sector is:

$$\mathcal{E}_t \left(\frac{F_{t+1}^*}{R_t^*} - F_t^* \right) - \mathcal{E}_t \left(\frac{B_{t+1}^*}{R_{Ht}^*} - B_t^* \right) - \left(\frac{B_{t+1}}{R_t} - B_t \right) = \mathcal{E}_t Q_t^* X_t + P_t Y_t - W_t, \quad (4)$$

where X_t is the endowment of commodities sold to the rest of the world at foreign-currency price Q_t^* , and Y_t is the endowment of non-tradable domestic goods.

We denote with $TR_t \equiv \mathcal{E}_t Q_t^* X_t + P_t Y_t$ the aggregate national income in local currency and with W_t the wage income commitment to the households set in local nominal terms. While we abstract from price rigidities given the large size of the shock and quick inflation response in the economy, the nominal wage commitment W_t is in some ways similar to the downward wage rigidity as it can be relaxed with price inflation, and the government infrequently resets the wage commitment to satisfy the government budget constraint. The budget constraint (4) can be generalized to include other government expenditures G_t which do not contribute to the household consumer surplus (e.g. military expenditure) with the effects of G_t on allocations equivalent to that of a reduction in the disposable output Y_t .

Finally, F_t^* are the (net) foreign assets and R_t^* is the world interest rate in foreign currency. The liabilities of the government sector are the local- and foreign-currency bonds, B_t and B_t^* , held by the households. Therefore, $A_t^* \equiv F_t^* - B_t^*$ are the net foreign assets, or FX reserves, held by the government sector. The set of government policies includes a standard fiscal choice between borrowing from households B_{t+1} and adjusting expenditure commitment W_t , a conventional monetary policy tool R_t that pins down the path of domestic prices P_t , as well as accumulation (or decumulation) of FX reserves A_{t+1}^* . In addition, the government can use financial repression or capital controls that depress household rate of return on foreign-currency savings R_{Ht}^* below the international rate of return R_t^* .

International sanctions and shocks. The rest of the world is large. It exports to Russia the international tradable good C_{Ft} and imports from Russia commodities X_t at the relative price Q_t^*/P_t^* . The rest of the world imposes trade sanctions on the Russian economy. In this section, we capture them in a stylized way as shocks to trade prices Q_t^* and P_t^* , and thus the rest of the world can exogenously impose a deterioration of the Russian terms of trade Q_t^*/P_t^* . We relax this assumption in Section 3 by providing the full description of the international economy where we model Russia as a large exporter of commodities, as well as spell out the specific policy instruments used to impose sanctions.

In our baseline analysis, we also consider the effect of foreign asset freezes, which we capture as a reduction in the net foreign asset position F_0^* , as featured in (4). Financial sanctions are also associated with an increase in the household precautionary demand for foreign currency

Ψ_t due to a collapsing supply of alternative vehicles of savings, and in particular safe assets.¹⁰ Therefore, we consider the financial shock Ψ_t along with financial sanctions. We also allow for a general path of other exogenous shocks to endowment of domestic goods Y_t and the international interest rate R_t^* . The latter shock can proxy for additional financial sanctions that exclude the country from the financial market, while the domestic disposable output may decline as a result of the war and spillover effect from financial and trade sanctions on the domestic economy.

Equilibrium. The goods market clearing condition in the non-tradable sector is $C_{Ht} = Y_t$. The local-currency nominal interest rate R_t allows the government to control non-tradable price inflation P_{t+1}/P_t by choosing the slope of the household Euler equation, $\beta R_t \mathbb{E}_t \left\{ \left(\frac{C_{Ht}}{C_{Ht+1}} \right)^{1/\theta} \frac{P_t}{P_{t+1}} \right\} = 1$. This acts as a side equation that allows us to treat the path of prices P_t as chosen directly by monetary policy.

Households make their consumption and savings decisions taking as given the path of income W_t , prices P_t and $\mathcal{E}_t P_t^*$, and interest rates R_t and R_{Ht}^* . This leads to the import demand schedule:

$$C_{Ft} = \left(\frac{\mathcal{E}_t P_t^*}{P_t} \right)^{-\theta} \gamma Y_t, \quad (5)$$

where we used the domestic good market clearing condition $C_{Ht} = Y_t$. In turn, the household demand for foreign-currency bonds B_{t+1}^* satisfies the following Euler equation:

$$\beta R_{Ht}^* \mathbb{E}_t \left\{ \frac{P_t^*}{P_{t+1}^*} \left[\left(\frac{C_{Ft}}{C_{F,t+1}} \right)^{1/\theta} + \tilde{\kappa} C_{Ft}^{1/\theta} \left(\Psi_t - \frac{B_{t+1}^*}{P_{t+1}^*} \right) \right] \right\} = 1, \quad (6)$$

where $\tilde{\kappa} \equiv \frac{\theta}{\theta-1} \frac{\kappa}{\beta \gamma^{1/\theta}} \geq 0$. In addition to the conventional import consumption smoothing motive for savings, household currency demand (6) features the Ψ_t shock which reflects additional precautionary savings motive, or demand for safe assets. In particular, an increase in Ψ_t above the real value of household FX savings B_t^*/P_t^* results in a force to accumulate foreign-currency savings despite their, possibly, low expected return for households R_{Ht}^* .

Lastly, the path of import consumption must satisfy the intertemporal budget constraint of the country which combines the household and the government budget constraints (2) and (4). Expressing it in foreign-currency terms and using the non-tradable market clearing condition, we arrive at:

$$\frac{F_{t+1}^*}{R_t^*} - F_t^* = Q_t^* X_t - P_t^* C_{Ft}, \quad (7)$$

where the right-hand side is the country's net exports expressed in foreign-currency terms, $NX_t^* = Q_t^* X_t - P_t^* C_{Ft}$. Note that NX_t^* is also the inflow of new foreign currency (outflow if negative), while F_t^* is the stock of foreign currency held jointly by the households B_t^* and the government $A_t^* = F_t^* - B_t^*$. The country budget constraint features the world interest rate R_t^* in contrast with the household currency demand (6) which depends on R_{Ht}^* .¹¹

Taking the paths of endowments (X_t, Y_t) , export and import prices (Q_t^*, P_t^*) , the world interest rate R_t^* , and the financial shock Ψ_t as given, the equilibrium vector $(C_{Ft}, \mathcal{E}_t, B_{t+1}^*)$ satisfies import demand (5), the country budget constraint (7), and the household demand for

10. In the Russian context, the local stock market collapsed, home currency deposits were subject to inflation and bank-run risks, and access to foreign assets was constrained.

11. The gap between the world and the local interest rates R_t^* and R_{Ht}^* does not affect the aggregate country budget constraint because it only results in a transfer between the households and the government budget constraint (4).

foreign currency (6), given non-tradable goods market clearing $C_{Ht} = Y_t$, initial net foreign assets $F_0^* = A_0^* + B_0^*$, and government policies. The latter consist of reserve accumulation A_t^* , the path of nominal non-tradable prices P_t implemented by monetary policy R_t , and the extent of financial repression $R_{Ht}^* \leq R_t^*$ of foreign currency deposits. Note from the equilibrium system that $\mathcal{E}_t/P_t$ —a measure of the real exchange rate—is determined independently of monetary policy (inflation), and changes in home good inflation shift the path of the nominal exchange rate $\mathcal{E}_t$ one-for-one with P_t . Also note that, with $\tilde{\kappa} > 0$ in (6), Ricardian equivalence does not apply for savings in foreign currency because households cannot costlessly adjust B_t^* to offset the government asset position. Hence, the choice of government reserves A_t^* affects the equilibrium allocation.

To provide intuition for the results that follow, we focus on equilibrium dynamics shaped by the interplay between the country budget constraint (7) and the household Euler equation (6), characterizing the net supply of foreign currency to the economy and the household demand for foreign currency, respectively. Trade and financial sanctions affect the equilibrium dynamics via these two conditions, while the import demand schedule (5) acts as a side equations that pins down the exchange rate that supports this equilibrium allocation.

2.2. Trade sanctions

We begin with the analysis of permanent trade sanctions in a fully dynamic equilibrium environment. We prove an allocative equivalence result between import and export sanctions, with the equivalence supported by a differential equilibrium exchange rate adjustment. This result extends the logic of seminal Lerner (1936) symmetry between a uniform import tariff and a uniform export tax to a dynamic international macro environment. We then discuss instances where the equivalence between import and export sanctions fails.

For any equilibrium path characterized by exogenous shocks $\{X_t, Y_t, Q_t^*, P_t^*, R_t^*\}$, government policies $\{P_t, R_{Ht}^*, A_{t+1}^*\}$, and endogenous equilibrium outcomes $\{C_{Ft}, \mathcal{E}_t, B_{t+1}^*, F_{t+1}^*\}$, given the initial asset positions (A_0^*, B_0^*) , we consider two alternative trade sanctions policies operating via import and exports prices, respectively. Specifically, we consider a deterioration in the country's terms of trade Q_t^*/P_t^* brought about either by a reduction in export prices Q_t^* or an increase in import prices P_t^* . We denote with $\hat{Q}_t^* \equiv \log(Q_t^*/Q_t^*)$ the proportional (log) change in the export price in the new equilibrium relative to the original equilibrium, and similarly for other variables. Our baseline result focuses on a one-time unanticipated and permanent sanctions policies at $t_0 \geq 0$ such that for all $t \geq t_0$ and some $\tau > 0$:

$$\hat{Q}_t^* = -\tau < 0 \quad \text{or} \quad \hat{P}_t^* = \tau > 0. \quad (8)$$

Additionally, we allow for a one-time permanent freeze of net foreign assets $\hat{F}_t^* = -\tau$ at $t = t_0$. For concreteness, we assume—as was relevant in the case of Russia—that $F_0^*, A_0^* > 0$, and that the foreign asset freeze extends proportionally to both publicly and privately held assets, $\hat{A}_t^* = \hat{B}_t^* = -\tau$. Virtually none of our results hinge on these added assumptions.

Note that the two policies in (8) have the same effect of deteriorating the country's terms of trade by τ percent ($\tau \cdot 100$ log points, to be precise), while the asset freeze reduces the purchasing power of accumulated net foreign assets by the same factor. Without loss of generality, we focus on the case where $t_0 = 0$, and we discuss the case of anticipated and non-permanent sanctions below.

Proposition 1. *Permanent sanctions on imports, $\hat{P}_t^* = \tau > 0$ for all $t \geq 0$, are equivalent to a combination of permanent sanctions on exports, $\hat{Q}_t^* = -\tau < 0$, and a partial seizure of foreign*

assets $\hat{F}_0^* = -\tau$: both sets of sanctions result in the same path of reduced import quantities, $\hat{C}_{Ft} < 0$, and welfare. However, sanctions on exports (cum foreign assets) are associated with an additional depreciation of the exchange rate by τ percent relative to sanctions on imports.

To prove Proposition 1, rewrite the country budget constraint (7) in real units of imports C_{Ft} :

$$\frac{P_{t+1}^*/P_t^*}{R_t^*} \cdot \frac{F_{t+1}^*}{P_{t+1}^*} - \frac{F_t^*}{P_t^*} = \frac{Q_t^*}{P_t^*} \cdot X_t - C_{Ft}. \quad (9)$$

There are three distinct effects from trade sanctions. The first is the effect on the terms of trade Q_t^*/P_t^* common under both kinds of sanctions to diminish the feasible import consumption set. While export sanctions curb international revenues directly, import sanctions reduce the purchasing power of export revenues. Import sanctions have two additional effects: they reduce the purchasing power of already accumulated foreign assets, F_0^*/P_0^* , and, in general, affect the real rate of return on international savings, $R_t^* \frac{P_t^*}{P_{t+1}^*}$. The latter effect is absent under permanent sanctions, as P_t^* increases proportionally for all t . The former effect, however, is always present when $F_0^* \neq 0$. Therefore, the equivalence between the two types of sanctions requires that export sanctions are combined with a partial seizure of accumulated net foreign assets to induce a proportional reduction in the real value of F_0^*/P_0^* (cf. Farhi *et al.*, 2014, in the context of fiscal devaluations). Finally, we note that the Euler equation (6) is equivalently satisfied under both policies for the same lower path of C_{Ft} and the same real value of foreign currency holding by the households B_{t+1}^*/P_{t+1}^* with the unchanged path of the interest rate R_{Ht}^* .¹² This completes the proof that the same path of imports C_{Ft} and the same evolution of real net foreign assets F_t^*/P_t^* occurs under both sanctions regimes, resulting in the same lower welfare.

To establish the consequences for the exchange rate, we study the import demand schedule (5), which we rewrite as:

$$\frac{\mathcal{E}_t}{P_t} = \frac{1}{P_t^*} \left(\frac{C_{Ft}}{\gamma Y_t} \right)^{-1/\theta}. \quad (10)$$

Since the path of import consumption C_{Ft} changes identically, the path of the exchange rate is different under the two sanction policies. While lower imports $\hat{C}_{Ft} < 0$ are supported by an exchange rate depreciation $\hat{\mathcal{E}}_t > 0$, import sanctions with $\hat{P}_t^* > 0$ have an additional effect to appreciate the exchange rate.¹³

At an intuitive level, the exchange rate movements ensure in both cases that the allocation afforded by the country budget constraint is also consistent with consumer optimization over expenditure on imports and domestic goods. While the country budget constraint shrinks equivalently in real terms in both cases, the mechanism is different—operating either via a reduction of export income or, alternatively, an increase in the cost of imports. Therefore, in the former case, the exchange rate must depreciate to discourage import consumption and bring it in line with the new budget constraint. In the latter case, the exchange rate must appreciate to offset expenditure switching from higher import prices that would otherwise result in excess demand

12. When the economy is non-Ricardian, *i.e.* $\kappa > 0$, the equivalence requires that real official FX reserves, $A_t^*/P_t^* = (F_t^* - B_t^*)/P_t^*$, follow the same path under the two sanctions regimes, adjusting downwards because of either higher import prices P_t^* or a partial seizure of central bank's assets. This condition can hold irrespective of whether the government actively uses FX interventions or not in response to the sanctions shock. It is trivially satisfied in the special cases with no official reserves $A_t^* = 0$ or no household FX holdings $B_t^* = 0$.

13. The real exchange rate, $\mathcal{E}_t/P_t$, tracks the nominal exchange rate $\mathcal{E}_t$ when monetary policy stabilizes domestic prices P_t . Indeed, the appreciation and depreciation forces from trade sanctions are *real*, and characterize the adjustment in the real exchange rate $\mathcal{E}_t/P_t$.

for non-tradables leaving export revenues partially unused. This is a macroeconomic version of the Lerner (1936) symmetry logic by which an import tariff is equivalent to an export tax as they result in the same allocation with depressed international trade flows yet sustained with a differential movement in prices.¹⁴

Before delving deeper into the intuition for the exchange rate result, we provide a further equilibrium characterization of the dynamic response to permanent trade sanctions in two instructive special cases which correspond to the economy starting in a stationary equilibrium prior to the sanctions shock:

Proposition 2.

- (a) *If either $\kappa = 0$ or $B_0^* = \Psi_t \equiv 0$, then the two permanent trade sanctions policies result in $\hat{C}_{Ft} = -\tau < 0$ for all $t \geq 0$ with a permanent exchange rate appreciation $\hat{\mathcal{E}}_t = -\frac{\theta-1}{\theta}\tau < 0$ under import sanctions and depreciation $\hat{\mathcal{E}}_t = \frac{1}{\theta}\tau > 0$ under export (cum foreign asset) sanctions.*
- (b) *Alternatively, with $\kappa > 0$ and $\Psi_t \equiv \frac{B_0^*}{P_0^*} > 0$, there is an additional transitory depreciation of the exchange rate in both cases relative to its respective long-run levels.*

The former case corresponds to the immediate adjustment to a permanent real income shock, which happens even in a generally non-stationary stochastic environment. In this case, permanent sanctions of both kinds result in a permanent reduction of import consumption, $\hat{C}_{Ft} = -\tau$, which simultaneously satisfies the country budget constraint (9) and the household Euler equation for foreign-currency savings (6).¹⁵ This common permanent adjustment is supported with a differential exchange rate movement in (10) to equilibrate the currency market: namely, a permanent depreciation under export sanctions and a permanent appreciation under import sanctions:

$$\hat{\mathcal{E}}_t = -\frac{1}{\theta}\hat{Q}_t^* = \frac{1}{\theta}\tau > 0 \quad \text{versus} \quad \hat{\mathcal{E}}_t = -\frac{\theta-1}{\theta}\hat{P}_t^* = -\frac{\theta-1}{\theta}\tau < 0. \quad (11)$$

In the second case with $\kappa > 0$ and $\Psi_t > 0$, the non-Ricardian term in the household Euler equation (6) requires an additional dynamic adjustment to the permanent sanctions shock. Indeed, the sanctions-induced decline in the available foreign assets or their international purchasing power, B_t^*/P_t^* , motivates the households to delay import consumption and accumulate foreign-currency savings until the bliss point is reached again. This increased FX demand results in an additional depreciation of the exchange rate in the short run, over and above the respective long-run adjustment emphasized in the first case of the proposition. Thus, permanent trade sanctions in this case additionally trigger an effective financial shock and ensuing depreciation of the kind we analyze below in Section 2.3. In Section 4, we further show that non-Ricardian dynamics are important *quantitatively* in response to temporary trade sanctions.

14. According to Lerner symmetry, an import tariff results in a trade surplus on impact, which must be eliminated in equilibrium by means of an increase in the relative wage at home (an appreciation); an export tax does the reverse on impact, and requires a reduction in the home relative wage (a depreciation). Nonetheless, the real wage in terms of the home consumption basket declines in the same way in both cases, while the real exchange rate moves differentially.

15. Note that when either $\kappa = 0$ or $B_t^* = \Psi_t = 0$ for all $t \geq 0$, the Euler equation (6) effectively becomes $\beta R_{Ht}^* \mathbb{E}_t \left\{ \left(\frac{C_{F,t+1}}{C_{F,t}} \right)^{1/\theta} \frac{P_t^*}{P_{t+1}^*} \right\} = 1$, so that proportional shifts in P_t^* and $C_{F,t}^*$ for all t leave it unchanged, and hence $B_t^* = 0$ for all $t \geq 0$ remains a part of the equilibrium path starting from $B_0^* = 0$, as stated in the proposition.

Stationary equilibrium. To further spell out the forces behind the equilibrium exchange rate adjustment, we consider the special case of a stationary equilibrium with $R_{Ht}^* = R_t^* = 1/\beta$ and in the absence of foreign-currency demand shocks, $\Psi_t = 0$. Starting with $B_0^* = 0$, this equilibrium features $B_t^* = 0$ for all t , irrespective of the value of the country's net foreign assets F_0^* , eliminating the need to further utilize the Euler equation. Then, any permanent sanctions shock results in no transition dynamics and a jump to a new stationary equilibrium with

$$C_{Ft} = \frac{Q_t^* X_t + (1 - \beta) F_0^*}{P_t^*}, \quad (12)$$

and the new value of the exchange rate given by (10). This provides a complete closed-form characterization of the equilibrium allocation.

Condition (12) characterizes the budget-feasible level of consumption. It illustrates the equivalence of all trade sanctions—whether on imports P_t^* , exports Q_t^* , or foreign assets F_0^* —in their impact on import consumption and welfare. Then, condition (10) determines the value of the exchange rate that supports this quantity of imports. While both import and export sanctions tighten the budget constraint by reducing the real purchasing power of export revenues, they have a differential effect on the currency market and the exchange rate—depending on whether they curb export revenues or increase the cost of imports.

There are two equivalent ways to see this result, as we illustrate in the two panels of Figure 2. From the perspective of the currency market, in the right panel (b) of the figure, export and foreign asset sanctions reduce the supply of foreign currency to the economy, while import sanctions limit the demand for foreign currency to purchase imports.¹⁶ To clear the currency market, the country's exchange rate depreciates when FX becomes scarce under export sanctions and appreciates when FX becomes relatively abundant under import sanctions.

The equilibrium in the goods market is a direct reflection of the equilibrium in the currency market, as we illustrate in the left panel (a) of Figure 2 which restates the equilibrium conditions in terms of goods flows. Import sanctions shift inward the import demand schedule (10), and, absent an exchange rate appreciation, the economy will not be willing to use all of its unsanctioned export proceeds on now more expensive imports. As a result, an exchange rate appreciation must happen in equilibrium to ensure that aggregate imports still exhaust the country budget constraint (see Lorenzoni and Werning, 2023). Our approach of focussing on the currency market is less conventional in real international macro models, but provides a clearer intuition in this case and proves particularly useful later when we consider financial FX savings as an additional source of foreign currency demand.

2.2.1. Fiscal revenues and the real cost of living. The allocational equivalence of import and export sanctions in Proposition 1 further extends to the government fiscal balance, consumer price inflation, and the real cost of living. Recall that fiscal revenues in the government budget constraint (4) equal the nominal national income, $TR_t = \mathcal{E}_t Q_t^* X_t + P_t Y_t$, yet our results generalize to the case where fiscal revenues are collected differentially on exported and domestic value added.

16. The last statement is true when the elasticity of substitution between imported and domestic goods is greater than one, $\theta > 1$ as we assume, and hence an increase in import prices reduces the expenditure share on imports, making foreign currency less demanded. When $\theta < 1$, the rest of the world has an unlimited economic power over the economy with minimal sanctions, and this case is unrealistic in the real world with much of substitution operating effectively via non-aligned foreign countries. See the working paper version Itskhoki and Mukhin (2022) for the analysis in an interesting limiting case with $\theta = 1$, i.e. the Cobb-Douglas case.

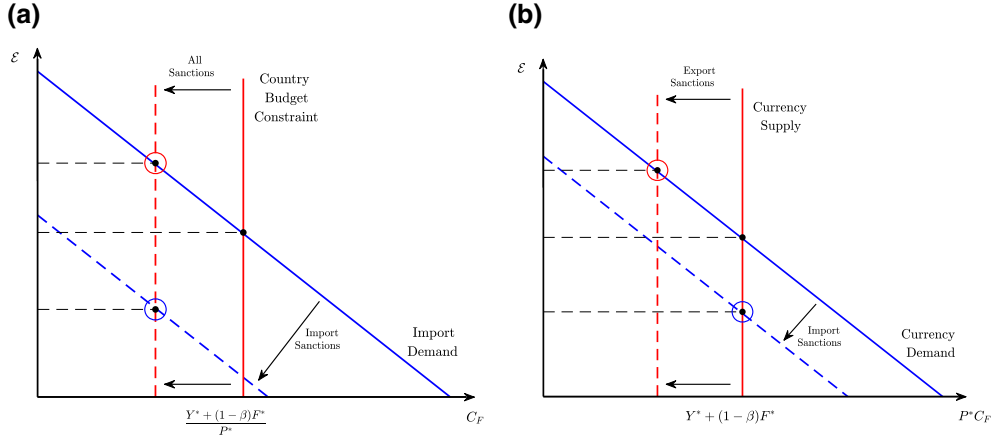


FIGURE 2

Trade sanctions and the exchange rate. (a) Goods market equilibrium and (b) Currency market equilibrium

Note: The left panel describes the equilibrium in the goods market, while the right panel describes the equilibrium in the currency market. In both cases, figures plot the stationary equilibrium conditions (10) and (12), with the exchange rate ε against real imports C_F in the left panel and against import expenditure $P^* C_F$ in the right panel. Export sanctions shift (12) leftward in both panels, while import sanctions do the same only in the left panel. Import sanctions additionally shift inward (10) in both panels

Proposition 3. *Permanent import and export (cum foreign asset) sanctions have identical effects on the fiscal revenues of the government sector, as well as on the consumer price inflation and the real cost of living $\mathcal{P}_t$, for a given monetary policy response P_t .*

We can directly evaluate fiscal revenues TR_t in (4) and the ideal consumer price index $\mathcal{P}_t$ using the equilibrium expression for the exchange rate (10). We have:

$$TR_t \equiv \varepsilon_t Q_t^* X_t + P_t Y_t = P_t \left[Y_t + \frac{Q_t^*}{P_t^*} \left(\frac{\gamma Y_t}{C_{Ft}} \right)^{\frac{1}{\theta}} \right], \quad (13)$$

$$\mathcal{P}_t \equiv [P_t^{1-\theta} + \gamma (\varepsilon_t P_t^*)^{1-\theta}]^{\frac{1}{1-\theta}} = P_t \left[1 + \gamma \left(\frac{\gamma Y_t}{C_{Ft}} \right)^{\frac{1-\theta}{\theta}} \right]^{\frac{1}{1-\theta}}.$$

From Proposition 1, C_{Ft} follows the same reduced path under both sets of sanctions, which in both cases involve a deterioration in the terms of trade Q_t^*/P_t^* by τ log points. In particular, in the special case of Proposition 2a with a permanent import quantity adjustment, $\hat{C}_{Ft} = -\tau$, we can evaluate the proportional loss in fiscal revenues and the additional consumer price inflation relative to the equilibrium path without sanctions as follows:

$$\widehat{TR}_t = -\chi_t \cdot \frac{\theta-1}{\theta} \cdot \tau < 0 \quad \text{and} \quad \widehat{\mathcal{P}}_t = \mu_t \cdot \frac{1}{\theta} \cdot \tau > 0, \quad (14)$$

where $\chi_t \equiv \frac{\varepsilon_t Q_t^* X_t}{\varepsilon_t Q_t^* X_t + P_t Y_t}$ is the revenue share of exports and $\mu_t \equiv \frac{\varepsilon_t P_t^* C_{Ft}}{\varepsilon_t P_t^* C_{Ft} + P_t C_{Ht}}$ is the expenditure share on imports.¹⁷ As before, τ is the size of terms of trade deterioration induced by either kind of sanctions policy and θ is the elasticity of import demand which determines the magnitude of the equilibrium exchange rate adjustment (recall (11)).

As could be expected, the effect of import sanctions on the costs of living is proportional to the share of imports in expenditure μ_t , while the effect of export sanctions on fiscal revenues is proportional to the share of government revenues from exports χ_t , and this generalizes to the case when revenues need to be raised with taxes. What is remarkable, however, is the general equivalence between export and import sanctions in their effects on fiscal revenues and inflation. For example, import sanctions have exactly the same impact on fiscal revenues even when no taxes are levied on imports and all tax revenues come from exports, and export sanctions with no direct impact on import prices have the same equilibrium effect on consumer prices. This is the case because of the equilibrium adjustment in the exchange rate ε_t : the appreciation under import sanctions lowers local-currency fiscal revenues from exports, while the depreciation under export sanctions increases consumer prices.¹⁸

The results from Proposition 3 are more general than it might seem at first. First, it is not just the nominal home-currency fiscal revenues that decrease identically, but also the purchasing power of fiscal revenues in terms of aggregate consumption $\frac{TR_t}{P_t}$ and in terms of imports $\frac{TR_t}{\varepsilon_t P_t^*}$ (see also Barbiero *et al.*, 2019). Second, as import and export sanctions reduce fiscal revenues and tighten the government budget constraint (4), they might put a pressure on the government to cut nominal wages W_t , inflate them away via higher domestic prices P_t , or raise taxes with potentially distortionary effects on home output (captured with an exogenous reduction in Y_t in our simple endowment model).¹⁹ The government may also want to respond to a rising cost of living P_t with a tight or accommodative monetary and fiscal policy changing the paths of P_t , W_t , and/or Y_t . None of these endogenous policy responses invalidate the equivalence in Proposition 3: since the direct effect of the two types of sanctions on TR_t , P_t , and other allocation-relevant quantities is the same, any policy that depends only on such variables—and not on the exchange rate—responds in the same way to import and export sanctions.

2.2.2. Policy implications. Theoretical results above clarify several key issues that were at the heart of the policy debate about the effects of sanctions on the Russian economy in 2022. In particular, the fact that export and import sanctions have the same allocative, fiscal and welfare implications but the opposite effects on the exchange rate implies that, without further information, one cannot infer the effectiveness of sanctions from the dynamics of the exchange rate. For example, the appreciation of the ruble in summer 2022 is in line with the fact that the Western coalition prioritized import sanctions and should not be interpreted to mean the impotence of such restrictions.

Proposition 1 also sheds light on the discussion whether the two types of trade sanctions should be treated as substitutes or complements in terms of inflicting damage on the economy.

17. These linear formulas are exact for small τ , and the non-linear formulas are provided in Appendix A using the exact hat algebra approach around the general pre-sanctions equilibrium path characterize by $\{\chi_t, \mu_t\}$.

18. In addition to their direct effect on government revenues, sanctions that induce a decline in disposable home output, $C_{Ht} = Y_t$, also increase fiscal deficit and consumer prices via the exchange rate appreciation in (10) as a result of a negative income effect on import demand.

19. Consider, for simplicity, a stationary version of the government budget constraint (4) with $R_t = R_t^* = R_{Ht}^* = \frac{1}{\beta}$ and $B_t = 0$: $\frac{W_t}{P_t} = Y_t + \frac{\varepsilon_t P_t^*}{P_t} \cdot \left[\frac{Q_t^*}{P_t^*} \cdot X_t + (1 - \beta) \frac{F_t^* - B_t^*}{P_t^*} \right]$. Both kinds of sanctions reduce the square brackets by τ percent, while the exchange rate term in front partially relaxes it by τ/θ percent according to (10). All in all, the government needs to either reduce W_t or increase P_t .

While the same economic impact can be achieved by means of either export or import sanctions, their combined effect is cumulative and both kinds of sanctions matter on the margin, provided that international trade is not fully shut down. The latter condition is all but certain to hold in practice given the rerouting of trade and the substitution of imports and exports away from sanctioning coalition towards third countries.

2.2.3. Limits of equivalence. Propositions 1 to 3 emphasize a general equivalence result for import and export sanctions in terms of their allocative effects despite the differential exchange rate adjustment. Importantly, this is not a knife-edge result in the sense that it offers a reliable benchmark for qualitative and quantitative analysis of sanctions even when the exact conditions of equivalence do not hold, as we further explore in the quantitative Section 4. Nonetheless, a few important caveats are in order.

First, the original Lerner (1936) symmetry emphasizes the requirement of a *uniform* import tariff and export subsidy, *i.e.* that they apply equally to every traded good in the context of a static international trade model. In a dynamic macroeconomic environment, the uniformity across goods is not central. We do not need to specify what subsets of countries are engaged in sanctions and which subsets of goods are excluded from trade as long as we condition on the overall decline in the country's price of exports Q_t^* and the increase in the cost of imports P_t^* , where these objects are the ideal price indexes that incorporate the implied substitution responses (see Section 3). Instead, it is the uniformity across periods that is crucial for the equivalence in a dynamic setting. This includes taxing all past as well as future trade flows. As it turns out, total net foreign-currency assets F_t^* provide a sufficient statistic for past trade imbalances, and this is the reason why dynamic Lerner symmetry requires export sanctions to be combined with an additional asset freeze on these accumulated net exports.

Second, the uniformity condition fails and Lerner symmetry does not apply when trade sanctions are anticipated before they are imposed or are expected to be lifted in the future.²⁰ In particular, while both types of trade sanctions worsen the terms of trade Q_t^*/P_t^* , temporary import sanctions also result in a positive interest rate shock $R_t^* \frac{P_t^*}{P_{t+1}^*}$, which reduces welfare for borrowers and improves welfare for lenders. As a result, export sanctions have larger effect on countries running a current account surplus and import sanctions affect more economies with a current account deficit. We formally study this and other related effects of anticipated and temporary sanctions in Itskhoki and Mukhin (2023a).

Third, it is natural to ask about the interactions between trade and financial sanctions given that the two policies are often imposed together in practice. Interestingly, even though borrowing constraints affect the equilibrium allocation when countries run a current account deficit, they do not compromise Lerner symmetry between permanent import and export sanctions.²¹ In contrast, financial restrictions may amplify the differences between temporary trade sanctions. Front-loading export sanctions results in a larger drop in imports and a larger exchange rate depreciation if the country is unable to borrow internationally and cannot smooth out the negative shock over time. Instead, temporary import sanctions provide incentives to delay consumption of foreign goods until sanctions wane, which relaxes the borrowing constraint.²²

20. A more general equivalence for dynamic, partially anticipated sanctions shocks requires the use of additional capital controls instruments to offset the tilt in the FX demand in (6) and the budget constraint (9) induced by anticipated changes in import prices P_t^* (see Farhi *et al.*, 2014).

21. Furthermore, if the country completely loses access to global financial markets and its trade must be balanced state-by-state, import and export sanctions become equivalent irrespective of their dynamic time path.

22. That said, import sanctions that result in additional foreign asset accumulation expose the country to the risk of future rounds of financial sanctions and asset freezes.

Finally, deviations from Lerner symmetry may arise when financial constraints on the economy are amplified by the exchange rate depreciation. Despite the same terms-of-trade effect, import and export sanctions have asymmetric implications for the exchange rate and may result in a differential tightening of the borrowing limits (see *e.g.* Bianchi, 2011) or the debt overhang constraint in the domestic economy (see *e.g.* Eggertsson and Krugman, 2012). For example, a depreciation of the exchange rate increases the real burden of debt issued in foreign currencies and can result in a bank run, financial crisis and an economic recession. It follows from Proposition 1 that—if not offset by government bailouts, bank holidays, or partial defaults—export sanctions may have more negative effects via the exchange rate channel than import restrictions, especially in highly dollarized economies.²³

2.3. Financial sanctions and financial repression

We now study the effects of financial sanctions in the context of the same equilibrium system (5)–(7) by considering a response to a foreign-currency demand shock Ψ_t in (6). Such shock is likely to arise for two reasons. First, an increased demand for foreign-currency savings by households may arise due to elevated uncertainty and the collapse of alternative home-currency vehicles for savings as a result of the war and sanctions. Second, the risk of being hit by further rounds of sanctions and retaliation policies makes foreign investors unwind their financial positions in the economy under sanctions. This leads to sudden-stop dynamics with foreigners selling local assets in exchange for foreign currency, as we quantify in the data in Section 4. In the model, this is also captured in a reduced-form as an increase in Ψ_t which acts as a summary statistic for the aggregate financial shock induced by the war and sanctions. The government may respond to this shock with FX interventions, A_t^* , and financial repression, $R_{Ht}^* < R_t^*$.²⁴

For simplicity, we focus on the case where the original dynamic equilibrium path features $\Psi_t = B_t^*/P_t^* \equiv \tilde{\Psi} > 0$ and $R_t^* \equiv \frac{1}{\beta}$ for all t , and consider a permanent unanticipated shock to FX demand $\hat{\Psi}_t = \psi > 0$ for all $t \geq 0$.²⁵ Using the equilibrium system (5)–(7), we prove in Appendix C:

Proposition 4. *Consider a permanent increase in foreign currency demand $\hat{\Psi}_t = \psi$ for all $t \geq 0$.*

- (a) *If the government accommodates the shock by selling FX reserves $\hat{A}_t^* < 0$ such that $\hat{B}_t^* = \psi$, then import quantities, the exchange rate and total net foreign assets do not respond to the shock, $\hat{C}_{Ft} = \hat{E}_t = \hat{F}_t^* = 0$, and follow the original equilibrium path. This is a welfare-maximizing policy response.*

23. We omit such balance sheet effects from our analysis as they are likely quantitatively unimportant in the case of 2022 Russian sanctions. As a result of 2014 financial sanctions and government policy response, Russia had no net foreign-currency debt and only limited dollarization of contracts within the economy by 2022. A record-breaking current account surplus in the first year of the war more than undid the effects of the new financial sanctions.

24. Our analysis, in general, nests as a special case the situation of financial autarky defined as an inability to access international borrowing, $F_t^* \geq 0$, or collect return on FX savings, $R_t^* \leq 1$. These additional constraints were of limited effect on Russia in 2022, which was already significantly cut off from international borrowing after 2014, and ran a combination of current account and fiscal surpluses with $F_t^* > 0$ prior to the start of the war. We leave the analysis of “payment system sanctions” to future work. For further discussion, see Itskhoki and Ribakova (2024).

25. The focus on a one-time permanent shock is for convenience only, and the results can be generalized to an arbitrary dynamic shock process (see Itskhoki and Mukhin, 2021). Our quantitative analysis in Section 4 relaxes these assumptions.

- (b) *If the government is passive, $\hat{A}_t^* = 0$ and $R_{Ht}^* = R_t^*$, then import quantities decline $\hat{C}_{Ft} < 0$ and the exchange rate depreciates $\hat{\mathcal{E}}_t > 0$ for $t \in [0, T]$ and some $T > 0$, while FX savings B_t^* and net foreign assets F_t^* are accumulated until the new long-run equilibrium is reached.*
- (c) *Without FX interventions, $\hat{A}_t^* = 0$, there exists a tax on foreign currency purchases by the households which results in $R_{Ht}^* < R_t^*$ such that import quantities, the exchange rate and foreign-currency assets remain unchanged, $\hat{C}_{Ft} = \hat{\mathcal{E}}_t = \hat{B}_t^* = \hat{F}_t^* = 0$ for all t . This involves a household welfare loss from the unaccommodated currency demand shock $\hat{\Psi}_t = \psi$.*

The logic of the proof relies on the fact that—from the perspective of equilibrium dynamics—there is a symmetry in the way the financial shock Ψ_t , the local-market FX interest rate R_{Ht}^* , and FX interventions $\hat{A}_t^*$ enter the equilibrium system. Indeed, all these variables affect only the household Euler equation (6), but not the country budget constraint (7) or the import demand schedule (5). As a result, the effect of the Ψ_t shock can be fully offset by either FX interventions or financial repression. Without either intervention, the increased currency demand of the household constrains the joint evolution of imports C_{Ft} and FX savings B_t^* . In all case, the exchange rate $\mathcal{E}_t$ adjusts to sustain the equilibrium dynamics consistent with the country budget constraint.

We now zoom in on specific mechanisms operating in each case. In general, an increase in Ψ_0 leads to $B_0^*/P_0^* < \Psi_0$ on impact, resulting in an increased foreign currency demand by households. Proposition 4 emphasizes the three different ways in which this excess demand can be accommodated. First, increased household demand for foreign currency can be accommodated with the official FX interventions, whereby FX reserves A_0^* are sold to the households without changing the overall net foreign assets of the country, $F_0^* = A_0^* + B_0^*$. Assuming FX reserves are sufficient, this allows to fully eliminate the fluctuations in import consumption and the exchange rate. This ensures that both (6) and (7) are satisfied for the original path of C_{Ft} , $\mathcal{E}_t$ and F_t^* despite the shock $\hat{\Psi}_t$. From the normative perspective, such policy is optimal, akin to a Friedman rule, as it accommodates the currency demand of the households without distorting their consumption and savings decisions.²⁶

Second, when FX interventions are infeasible due to insufficient FX reserves or sanctions on the central bank, the laissez-faire equilibrium response to the currency demand shock is an exchange rate depreciation which forces the households to cut down on their import consumption C_{Ft} and accumulate foreign currency arising from the resulting trade surplus. The country accumulates net foreign assets F_t^* along with B_t^* , and over time B_t^*/P_t^* increases towards the new value of Ψ_t . Foreign asset accumulation happens at the cost of reduced imports along the transition path. Over time, imports C_{Ft} gradually recover and slightly overshoot in the long run (if $R_t^* > 1$), reflecting the increased net foreign asset position of the country. In parallel, the exchange rate $\mathcal{E}_t$ that depreciated on impact then gradually appreciates, reflecting the accumulation of the local FX supply. Figure 3 provides an illustration: steeper foreign currency savings demand κ implies faster accumulation of foreign currency, which in turn requires a larger initial drop in imports and depreciation of the exchange rate.

Finally, an alternative to FX interventions is a policy of financial repression of foreign-currency deposits by means of direct or indirect taxation (*e.g.* caps on withdrawal or conversion). We capture this policy with a resulting wedge in the local-market interest rate on FX savings,

26. See [Itskhoki and Mukhin \(2023b\)](#) for the analysis of the optimal FX interventions in a more general environment.

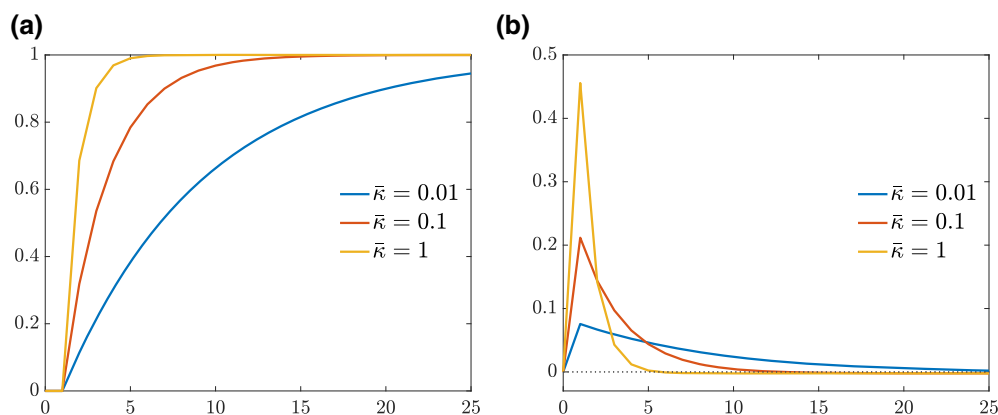


FIGURE 3

Laissez-faire response to FX demand shock Ψ_t . (a) Net foreign assets, $B_t^*/(\bar{P}^* \bar{C}_F^*)$ and (b) Exchange rate, $\log \mathcal{E}_t$

Note: The figure plots impulse responses—of the household’s holdings of foreign currency (as a share of pre-shock imports) in the left panel and of the exchange rate in the right panel—to a permanent increase in foreign currency savings demand Ψ_t equal to the country’s monthly imports and corresponding to the long-run increase in B_t^* in the left panel. One period corresponds to one month, $\beta = 0.96^{1/12}$, $\beta R_t^* = 1$; we use $\theta = 1.5$ and three different values of the currency demand parameter $\bar{\kappa} \equiv \frac{\theta \kappa / \beta}{\theta - 1} (\bar{C}_F / \gamma)^{1/\theta}$

$R_{Ht}^* < R_t^*$, which discourages foreign currency savings B_t^* in (6), even when Ψ_t is high. This curbs the exchange rate depreciation and the associated reduction in imports. In other words, financial repression ensures that scarce foreign currency is used to buy imports C_{Ft} rather than hoard foreign cash B_t^* . While smoothing the path of imports and the exchange rate, just like under the optimal FX interventions, such policy results in household welfare losses from distorted foreign currency savings, as captured by $v(B_{t+1}^*/P_{t+1}^*; \Psi_t)$ in the utility (1).²⁷

Our discussion emphasizes the competing uses of foreign currency for import purchases and saving when the supply of FX to the economy is constrained. Proposition 4 also suggests a welfare ranking of policies. FX interventions that accommodate the currency demand shock dominate laissez faire. In turn, in a representative agent environment, the laissez-faire equilibrium dominates the equilibrium with financial repression that suppresses the currency demand shock, as we formally show in Appendix C.2. All mechanisms identified in Proposition 4 were partly at play in Russia in the aftermath of the invasion and sanctions.²⁸

The welfare ranking of policies raises two questions. First, why not always resort to FXI in response to increased private currency demand? Scarcity of official FX reserves limit their possible use, and financial sanctions such as asset freezes can dramatically reduce this capacity as well. The government can attempt to create synthetic foreign currency deposits for savers

27. The result that imports are undistorted relies on the assumption that the tax is paid only by agents that purchase foreign currency as a store of value, while importers are exempt from it and can freely exchange currencies to pay for foreign goods.

28. In the working paper version (Itskhoki and Mukhin, 2022), we provide direct evidence of financial repression in Russia in March–April 2022 applied differentially across foreign currencies, and as a result distorting the domestic-market bilateral exchange rates between currencies relative to their international exchange rates, a rather peculiar outcome. In quantitative Section 4, we calibrate both the path of FX interventions and the net effect of financial shocks and financial repression which are jointly consistent with the observed dynamics of the exchange rate.

not backed by foreign assets (*i.e.* $A_t^* = -B_t^* < 0$ with $F_t^* = 0$) and financed with future consolidated revenues. This creates a currency mismatch on the government balance sheet making it vulnerable to further exchange rate depreciation shocks and bank runs (*cf.* Krugman, 1979; Obstfeld, 1996). Furthermore, a government running a budget deficit might want to *increase* FX reserves and *depreciate* national currency further to boost local-currency revenues TR_t . As we discuss in Appendix C.3, even though such policy has no effect on the country's real income, it does provide a temporary fiscal relief by shifting household consumption over time.

Second, if financial repression is necessarily welfare-reducing, why do we observe it used often in practice? One possible explanation is that a depreciation of the exchange rate in response to currency demand shocks can destabilize financial markets and lead to output losses in the presence of balance sheet constraints discussed above. However, as we show in Appendix C.2, financial repression may also be an effective tool of redistribution—between consumers and savers—in heterogenous agent economies (*cf.* De Ferra *et al.*, 2020; Fanelli and Straub, 2021). In such economies, the exchange rate still plays an important allocative role even under financial autarky and financial repression. An exchange rate depreciation discourages imports by consumers, while financial repression of FX savings curbs such depreciations and hence supports import consumption. As a result, if many agents are hand-to-mouth consumers relative to few FX savers, financial repression may increase the utilitarian welfare objective.

3. SANCTIONS ON A LARGE COMMODITY EXPORTER

We now extend our analysis to accommodate the case in which the economy under sanctions is large in the commodity market and, thus, sanctions affect world commodity prices and foreign welfare. To this end, we lay out a fully specified model of the rest of the world. We also formalize various specific trade sanction policies that can be adopted by the rest of the world and study when they remain equivalent to the baseline import and export tariffs.

3.1. *The rest of the world*

We model the rest of the world to capture the fact that it is large relative to the economy under sanctions in all markets, but commodities, where by large or small we mean whether the country has the ability to affect world prices. Towards this goal, we assume that international households have a quasi-linear utility function in the internationally tradable good C_{Ft}^* and concave in the consumption of commodities C_t^* :

$$u_t^* = C_{Ft}^* + \frac{\eta}{\eta - 1} \gamma^{*\frac{1}{\eta}} C_t^{*\frac{\eta-1}{\eta}}, \quad (15)$$

where $\eta > 0$ is the elasticity of demand for commodities and $\gamma^* > 0$ parametrizes the commodity-intensity of the world consumption basket. Households maximize the expected intertemporal utility with a discount factor β .

The international economy enjoys endowments Y_t^* of the tradable good and X_t^* of commodities with international prices P_t^w and Q_t^w , respectively. It procures an additional quantity X_t of commodities from the economy under sanctions and sells in return a quantity C_{Ft} of the international good at prices Q_t^* and P_t^* , respectively. We denote with τ_t^Q and τ_t^P the corresponding wedges relative to the world prices Q_t^w and P_t^w such that:

$$Q_t^w = (1 + \tau_t^Q) Q_t^* \quad \text{and} \quad P_t^* = (1 + \tau_t^P) P_t^w. \quad (16)$$

Therefore, $\mathcal{T}_t^* = \frac{\tau_t^Q}{1+\tau_t^Q} Q_t^w X_t + \tau_t^P P_t^w C_{Ft} + \tau_t^F F_t^*$ are the rents resulting from sanctions, where the last term captures a seizure of fraction τ_t^F of the country's net foreign assets.

The market clearing conditions for the two goods are:

$$C_t^* = X_t^* + X_t \quad \text{and} \quad C_{Ft}^* + C_{Ft} = Y_t^*. \quad (17)$$

We denote with $s_t = \frac{X_t}{X_t^* + X_t} \in (0, 1)$ the share of the world commodity output provided by the sanctioned economy. International households choose consumption given the world consumer prices, resulting in the following demand schedule for commodities:

$$C_t^* = \gamma^* \left(\frac{Q_t^w}{P_t^w} \right)^{-\eta}, \quad (18)$$

which depends on the relative price of commodities with elasticity η . Note that the elasticity of the world relative price of commodities with respect to commodity supply from the sanctioned economy is given by $\partial \log(Q_t^w / P_t^w) / \partial \log X_t = -s_t / \eta < 0$.

To complete the model description, note that the Euler equation for savings is given by $\beta R_t^* \mathbb{E}_t \{P_t^w / P_{t+1}^w\} = 1$, and the world monetary authority chooses R_t^* to implement a desirable path of the world prices P_t^w . In particular, if the goal is to implement stable prices, $P_t^w = 1$, then the equilibrium interest rate equals $R_t^* = 1/\beta$.

3.2. Alternative sanctions policies

We first show how the small-economy results in Proposition 1 generalize to the environment with the rest of the world which imposes sanctions in the form of import and export tariffs, τ_t^P and τ_t^Q in (16), resulting in the transfer $\mathcal{T}_t^*$ equal to tariff revenues along with the value of sanctioned foreign assets. We show that the symmetry between import and export tariffs applies not just for the economy under sanctions, but also for the rest of the world, which generally benefits from such tariffs at the expense of the sanctioned economy. We then consider alternative sanctions policies other than tariffs and the resulting welfare consequences for the sanctioning coalition.

While the economy under sanctions is now large in the sense that the quantity of its exports X_t affect the world price Q_t^w , we still assume that the country is a price-taker in the world commodity markets. Since we model commodities as endowment, this is equivalent to assuming that all endowment is used. This convenient assumption is also empirically realistic in the context of sanctions against Russian commodity exports, as we discuss below. Furthermore, the general equivalence emphasized in our results does not rely on this assumption.

Proposition 5. *Permanent tariff on imports, $\tau_t^P = \tau$ for all $t \geq 0$, is equivalent to a permanent tax on exports, $\tau_t^Q = \tau$, combined with a partial seizure of foreign assets, $\tau_0^F = \frac{\tau}{1+\tau}$: both policies result in a permanent deterioration in the terms of trade for the economy under sanctions, $\frac{Q_t^*}{P_t^*} = \frac{1}{1+\tau} \frac{Q_t^w}{P_t^w}$, a decline in its imports C_{Ft} , and a welfare gain in the rest of the world equal to the transfer of wealth:*

$$\frac{1}{P_0^w} \sum_{t=0}^{\infty} \beta^t \mathcal{T}_t^* = \frac{\tau}{1+\tau} \left[\frac{F_0^*}{P_0^w} + \sum_{t=0}^{\infty} \beta^t \frac{P_t^w}{P_0^w} \frac{Q_t^w}{P_t^w} X_t \right], \quad (19)$$

while the paths of world prices Q_t^w and P_t^w , and export quantities X_t remain unchanged.

We, therefore, see that the equivalence of Proposition 1 extends to the impact on the rest of the world (see the prove in Appendix B).²⁹ With endowment of commodities, both import and export sanctions affect the terms of trade and the allocation of the imported good C_{Ft} , but not commodity exports X_t or world prices Q_t^w/P_t^w . Lerner symmetry holds for the rest of the world, as well as for the economy under sanctions. In particular, the rest of the world receives a transfer of rents resulting from tariffs. This transfer results directly in welfare gains without inflationary effects or loss of commodity consumption, and there is no need to accommodate such sanctions with monetary policy. The same is generally true when foreign assets are taxed, as this is by definition a pure transfer with no costs to sender, and these were indeed the first sanctions imposed on Russia following the invasion in 2022.

The assumption of endowment of commodities implies inelastic supply of exports from the economy under sanctions. As a result, the rest of the world can effectively extract the full surplus with the optimal tariff, manipulating the terms of trade to the limit. In Appendix B, we generalize this optimal tariff result to the case where the supply of commodities is elastic. In this case, the optimal tariff $\tau = 1/\varepsilon$ is finite and is inversely related to the export supply elasticity ε , irrespective of other elasticities (Johnson, 1953; Helpman and Krugman, 1989).³⁰ The equivalence between export and import tariffs still holds in this case by Lerner symmetry, yet now both tariffs distort the commodity supply X_t and the world commodity prices Q_t^w/P_t^w , resulting in a dead-weight loss and global inefficiency. Nonetheless, the rents from the tariff more than compensate the losses from commodity consumption in the rest of the world. The economy under sanctions necessarily loses and the rest of the world necessarily gains from such tariffs.

Alternative export sanctions. We now zoom in on export restrictions and consider the effects of alternative policies. There are two dimensions of export sanctions that ensure their equivalence to the baseline tariff policy in Proposition 5. First, the sanctions policy must implement the same physical allocation of export quantities with the path of X_t that remains unchanged under the endowment assumption. Second, the sanctions policy must result in the same real rent transfer $\mathcal{T}_t^*$ from the sanctioned economy to the rest of the world. If these two conditions are satisfied, the policy implements the same sanctioned path of import consumption C_{Ft} with the path of the exchange rate supporting it that is still given by (10).

With this general insight, we now consider two alternative policies: a price cap and a quantity restriction (or partial embargo). First, we note that the price cap achieves the same outcome as the tariff τ if the cap is set as fraction $1/(1 + \tau)$ of the world commodity price Q_t^w . This results in the export price $Q_t^* = Q_t^w/(1 + \tau)$ to the sanctioned country and the gap between Q_t^w and Q_t^* becomes rents that must be split in the rest of the world. If the distribution of these rents is of no concern—that is, whether they accrue to individual countries or to commodity intermediaries rather than the government—then the equivalence with the tariff applies, irrespective of whether the export supply of commodities were elastic or not.³¹

29. The mapping of taxes τ^Q , τ^P and τ^F into log-deviation in Proposition 1 is as follows: $\hat{Q}_t^* = -\log(1 + \tau^Q)$, $\hat{P}_t^* = \log(1 + \tau^P)$ and $\hat{F}_0^* = \log(1 - \tau^F)$, which is the reason why $\tau^F = \tau/(1 + \tau)$ in Proposition 5.

30. The reason why other elasticities do not matter is that the country under the optimal tariff buys imports according to its budget constraint irrespective of the elasticity of import demand, and the exchange rate adjustment supports this equilibrium outcome. Thus, the entire objective of the optimal tariff is to extract maximum surplus from the supply of exports, a monopsony outcome. For further discussion see Itskhoki and Mukhin (2025b).

31. In practice, total Russian oil export quantities remained remarkably stable throughout both 2022 and 2023 while it was facing significant export price discounts largely due to the relocation of its exports away from Europe and towards new customers in China, India and Turkey (Hilgenstock et al., 2023). See Johnson et al. (2023) for the analysis of the price cap under monopolistic distortion.

Matters are significantly different with a quantity restrictions on exports captured with a binding constraint $X_t \leq \check{X}_t$. We can see immediately that, as long as the export supply of commodities is inelastic, quantity restrictions distort the allocation and result in a dead-weight loss relative to a tariff or a price cap. However, this is specific to the inelastic case and does not generalize when the export supply of commodities is elastic. With a positive elasticity $\varepsilon > 0$, for any tariff τ , there exists a binding quantity restriction $\check{X}_t$ that mechanically implements the same path of export quantity allocations. Nevertheless, what is general for both inelastic and elastic cases is the difficulty to extract rents. This is particularly apparent in the inelastic case, where a quantity restriction results in a movement up the commodity demand schedule (18) and an elevated consumer price Q_t^w/P_t^w with rents up for grabs by whoever controls the distribution of commodities to consumer. Intuitively, the goal of the policy is to move down along the export supply curve, which is vertical in the inelastic case, rather than up the commodity demand curve (see Figure O1 in Appendix B). With elastic supply, it is always possible to implement the right quantity sliding up the demand curve, but equivalence additionally requires a second policy tool to collect the rents.

If rents cannot be captured, are quantity restrictions purely wasteful from the perspective of the rest of the world? On the one hand, the rest of world necessarily experiences a welfare loss. On the other hand, the economy under sanctions also loses export revenues on net, but only if the elasticity of commodity demand with respect to X_t is less than one, that is, $s_t/\eta < 1$. In this case, the loss from lower quantities X_t dominates the gain from improved terms of trade. In other words, the dead-weight loss from the policy is so large as to eliminate gains for either of the parties despite rents being captured by the sanctioned economy. Therefore, if the goal of the policy is to reduce export revenues despite own welfare costs, then quantity restrictions may achieve this goal, yet they are inferior to a tariff or a price cap (*cf.* Sturm, 2022).

Alternative imports sanctions. Relative to various export sanctions, the equivalence applies more broadly across a variety of import sanctions policies. First, we address the case where the aggregate imported good C_F consists of a continuum of imperfectly substitutable varieties. With all varieties being symmetric, we nest the case of a single imported good studied so far. More generally, the varieties of the imported good may correspond to various source countries or to various types of product. Consider now the situation where only a subset of imported varieties are subject to a tariff τ . We show in Appendix B that, from the perspective of the macroeconomic allocation, this is equivalent to a uniform import tariff studied earlier and given by:

$$1 + \tau_t^P = [1 - \delta_t + \delta_t(1 + \tau)^{1-\rho}]^{\frac{1}{1-\rho}}, \quad (20)$$

where $\rho > 0$ is the constant elasticity of substitution between varieties of import products and δ_t is the share of products under a tariff. This share may correspond to a subset of products or a subset of countries imposing sanctions.

The macroeconomic effect on the country under sanctions is still summarized by the aggregate path of τ_t^P in (20), which takes into account the substitutability of various import varieties. Naturally, a full sanctioning coalition can aim to ensure $\delta_t = 1$ and $\tau_t^P = \tau$. With incomplete coverage of sanctions, $\delta_t < 1$, it is necessarily the case that $\tau_t^P < \tau$, and this gap is increasing in ρ . In other words, the same aggregate effect requires increasingly larger individual sanctions τ the smaller is the sanctioning coalition and the more substitutable are the imported varieties.³²

32. When $\rho > 1$, we can think of $\tau \rightarrow \infty$ as a ban on a subset of imported varieties. The result in (20) continues to hold in this limit, and we have $\tau_t^P = (1 - \delta_t)^{1/(1-\rho)}$ under a ban on fraction δ_t of import varieties (formally, δ_t is

We also note that exact equivalence between τ_t^P and (τ_t, δ_t) in (20) fails for the rest of the world, as for a given τ_t^P , the case with $\delta_t \in (0, 1)$ creates misallocation of produced varieties with the associated cost borne by the foreign economy. This is generally a second-order effect (in τ_t) and it is quantitatively very small when the economy under sanctions is small in terms of its import share of global output, C_F/Y^* . However, this can be important in cases where the burden of implementing and enforcing sanctions is not evenly split within the rest of the world.

Finally, we discuss the case of a homogenous good C_F (that is, when $\rho \rightarrow \infty$) with a quantity constraint on imports, $C_{Ft} \leq \check{C}_{Ft}$. First, note that in this case the full sanctioning coalition is essential. Indeed, according to (20), $\tau_t^P \rightarrow 0$ when $\rho \rightarrow \infty$ for any $\tau > 0$, as long as $\delta_t < 1$. Intuitively, with perfect substitutability, it is sufficient to find one supplier that is willing to deviate from the policy of sanctions. However, with a full coalition, it is possible to implement an effective quantity limit. This quantity limit results in rents from selling the imported good to the country under sanctions. If and only if these rents are captured by the rest of the world, the quantity restrictions are equivalent to a tariff, echoing our results on exports sanctions.³³

To summarize, from the perspective of the economy under sanctions, a sufficient statistic for the impact of permanent trade sanctions is the change in the flow of export revenues adjusted for their purchasing power of imported goods—namely, the proportional change in $Q_t^* X_t / P_t^*$ irrespective of the composition of this change. In other words, the same impact can be achieved by means of reduces exports prices Q_t^* , reduced export quantities X_t , or increased import prices P_t^* . Matters are very different from the perspective of the sanctioning coalition, which aims to inflict a maximum deterioration in the terms of trade Q_t^* / P_t^* with a minimal impact on export quantities X_t and, by consequence, its own consumer prices Q_t^w / P_t^w . With a decrease in X_t , the rest of the world experiences loss of consumer surplus and inflationary pressures from increasing commodity prices, which may result in an overall welfare loss.

4. QUANTITATIVE EVALUATION

This section provides a quantitative evaluation of the ruble exchange rate dynamics combining together various financial and trade shocks discussed in the previous sections. We further discuss the implications of sanctions shocks for other variables of interest, including fiscal revenues, inflation and welfare—both in the economy under sanctions and in the rest of the world.

We calibrate the model parameters and shocks with the aim of matching salient features of the Russian economy which is large in the global commodity market. We adopt two alternative strategies to calibrate the paths of the shocks that drive our quantitative results. First, we reproduce our *ex-ante* calibration from the 2022 version of the paper (Itskhoki and Mukhin, 2022) based on the scarce data that were available in the first months after the start of the war and without targeting exchange rate moments. We show that this calibration provides a remarkable out-of-sample fit, predicting accurately the dynamics of the exchange rate in the following 2 years. Second, we develop an *ex-post* calibration that infers structural shocks from the observed macroeconomic dynamics up to September 2024 and, by construction, reproduces the path of the

the ex-ante expenditure share on the sanctioned varieties before the ban was in place). Our working paper Itskhoki and Mukhin (2022) explores the case of a ban when $\rho = 1$ and, thus, the limit of $\tau \rightarrow \infty$ cannot be simply taken.

33. Formally, binding quantity restriction $\check{C}_{Ft}$ translates into a unique change in $P_t^* \mathcal{E}_t / P_t$ according to (10) and a unique path of $P_t^* > P_t^w$ consistent with the country budget constraint (9). Together, these conditions characterize the equilibrium real exchange rate which follows the same path as under an import tariff, $1 + \tau_t^P = P_t^* / P_t^w$.

exchange rate within our sample. We show that the two approaches largely agree on the decomposition of the exchange rate into the contributions of different sanctions shocks and policy responses, confirming the quantitative importance of theoretical mechanisms discussed above.

Calibration. We solve the model using a first-order perturbation around a non-stochastic steady state, and we denote with small letters the log deviations of corresponding variables from their steady-state values.³⁴ The model is monthly and we focus on the period from February 2022 to September 2024, the last quarter with available data. The war started on 24 February 2022, and we label this month as $t = 0$, assuming the first shocks arrive by the end of this initial period.

Whenever possible, we rely on conventional values of parameters from the earlier literature. We set the monthly discount factor $\beta = 0.96^{\frac{1}{12}}$. We use $\theta = 1.5$ consistent with conventional values of the macro elasticity of substitution between home and foreign goods (Chari *et al.*, 2002; Feenstra *et al.*, 2014). With scarce empirical guidance, we set the bonds-in-the-utility parameter $\bar{\kappa} = 0.33$, which implies that the demand elasticity for dollar deposits with respect to dollar interest rate is equal to 3. This is a bit higher than the estimates for the U.S. money demand elasticity of 1–2 (Lucas and E, 2000; Ireland, 2009), but in line with the estimates of the foreign-currency demand elasticity in developing countries (Agénor and Khan, 1996).

We choose the expenditure share parameters $\gamma = 0.25$ and $\gamma^* = 0.04$ in (3) and (15), respectively, as well as the countries' steady-state endowments to match the share of imports in total spendings in Russia of 20%, the contribution of Russia to the world GDP of 2%, and its share in the global oil market of 12.5%. We set the value of the commodity demand elasticity $\eta = 0.05$ closer to the lower estimates in the literature capturing the short-run response at the global level (Bachmann *et al.*, 2024).

We hold constant the parameter values across the two calibrations of shocks. In the ex-ante calibration, we choose the path of shocks as simple autoregressive processes that resemble the early information on sanctions, as summarized in Appendix Table A1. About half (or \$300 billion) of Russian foreign assets were frozen in the first week of the war which corresponds to a permanent decrease in f_0^* by 12 months worth of imports. The beginning of the war was associated with a sharp increase in uncertainty, in demand for FX safe assets, and in capital outflows. We capture this shock with an increase in foreign currency demand, $\psi_0 = 1.5$, corresponding to 1.5 months of imports, with a half-life of one year.³⁵ As financial repression and FX interventions can partially offset the financial shock, we do not consider them separately and interpret ψ_t as the net effect of financial distress partially offset with government policies.

All other shocks arrive with a one month lag to capture the delayed effects of non-financial sanctions. Following early estimates, a fall in domestic output is calibrated to 5% with a half-life of 3 years. As Russian imports were down from a monthly level of \$30 billion before the war to \$17 billion in April and rebounded to \$24 billion in mid-summer, the import sanctions shock is calibrated to feature a 50% increase in the import price index on impact with a half-life of 4 months. To capture both a spike in energy prices in the first months of the invasion and an expected fall in export revenues as European countries switch to alternative sources of energy

34. We focus on a steady state in which all prices are normalized to one, $F^* = B^* = \Psi = 0$, and $R^* = R_H^* = 1/\beta$.

35. While it is difficult to obtain data on the demand for foreign currency, our calibration is broadly consistent with the combined \$20 billion increase in household FX cash holdings (reported by the Central Bank of Russia) and \$100 billion withdrawal from the Russian bond and equity funds by foreigners in February–March 2022 (reported by EPFR/Haver Analytics). We provide a further validation for the quantitative magnitude of this shock below.

imports, we introduce shocks to both Russian and the rest-of-the-world supply of commodities, x_t and x_t^* , that result in a temporary increase of export revenues of 50% with a half-life of 8 months and a permanent decline of 30%.³⁶ Finally, we abstract from monetary shocks that are hard to disentangle ex ante from inflation driven by import prices, and we omit shocks to foreign output y_t^* that are irrelevant for the economy under sanctions.

In the ex-post calibration, some shocks can be directly observed while other need to be backed out to match the observable data. In particular, FX reserves a_t^* are reported by the Central Bank of Russia, monetary shocks p_t and p_t^w correspond to consumer price indexes in Russia and the U.S., and domestic output y_t and y_t^* is proxied with real GDP in the two countries. The Russian commodity output is the difference between observable export revenues and commodity prices, $x_t = ex_t - q_t^*$, while the foreign commodity output x_t^* is calibrated to match the path of world commodity prices q_t^* .³⁷ Given other variables, Russian import prices p_t^* are inferred using the import demand schedule (5) to match the path of import expenditure. This provides the description of trade shocks.

The asset freeze f_0^* is calibrated as before. By contrast, we now recover the financial shock ψ_t as a residual, upon including all other shocks, that allows to perfectly fit the observed path of the exchange rate. This requires making an assumption about agents' expectations about the shock process, and our baseline is perfect foresight. We interpret the resulting ψ_t series as the net FX demand shocks partially offset by financial repression which we do not identify separately. We provide below a validation of the recovered ψ_t series using data on interest rate spreads and capital outflows (see Appendix E).

Figure O2 in Appendix D shows the time series used to calibrate the model and the inferred paths of the shocks that we feed into the model. We solve the model under a perfect foresight assumption, where as before the asset freeze and the financial shocks are revealed at $t = 0$, while the paths of other shocks become known with a one period lag, at $t = 1$. The results are largely unchanged under an alternative specification with shocks following a random walk with each period's innovation being unexpected. See Appendix D for further details about the data, the alternative calibrations, and the numerical algorithm used to solve the model.

4.1. Exchange rate dynamics

We now explore the dynamics of the exchange rate through the prism of our quantitative model. Figure 4 plots the realized path of the ruble exchange rate in the data, from February 2022 to September 2024, as well as the equilibrium path of the exchange rate in the ex-ante calibrated model. Even though the exchange rate is not directly targeted in this calibration, the simulated path closely resembles the dynamics of the ruble in the data—the exchange rate depreciates on impact by 50%, returns to the initial level about a month after the impact, and then keeps appreciating to a peak of 20% above the pre-war level at the four-month horizon. Calibrated originally in September 2022, when the ruble was still significantly appreciated, the model predicts a return of the exchange rate to pre-war level around February 2023—remarkably in line with the future

36. In the data, Russian monthly export revenues increased from \$35 billion pre-war to \$50 billion for the period of February to June and then began to decline as energy prices came down and Western countries substituted away from Russian oil and gas (Babina *et al.*, 2023).

37. Recall from our discussion in Section 3.2 that the outcomes for the sanctioned economy depend only on the path of the overall export revenues, while the decomposition of their dynamics into export quantities and commodity prices is central for the outcomes in the rest of the world. In matching the observed dynamics of export revenues and commodity prices, we do not need to take a stance on whether the commodity supply from Russia is elastic or inelastic, an assumption that would be essential for counterfactual analysis.

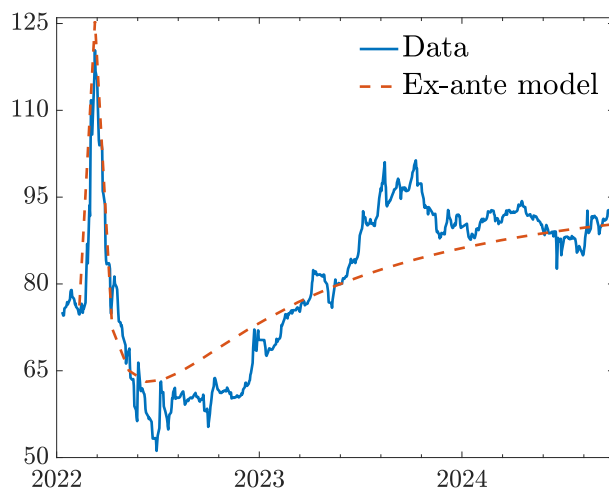


FIGURE 4
Exchange rate dynamics

Note: The figure plots the dynamics of the ruble-dollar exchange rate (in units of rubles per one dollar) in the data and in the model under the ex-ante calibration (with shocks as described in Appendix Table A1)

realization of the data. The model misses large swings in the exchange rate during political turmoil—the armed mutiny in the summer 2023 ([Wagner Group rebellion](#))—but captures well the long-run depreciation of the ruble by 20% towards the end of our sample.³⁸

One advantage of a structural model is that it allows us to decompose the dynamics of the exchange rate into various sanctions shocks. Figure 5 presents the results for the ex-ante and the ex-post calibrations, where the black lines correspond to the simulated paths of the exchange rate and the coloured bars show the counterfactual dynamics of the exchange rate when only one shock is present. Recall that the ex-post calibration matches the overall monthly path of the exchange rate exactly by construction. Despite different methodologies, the two calibrations largely agree on the underlying drivers of the exchange rate during this period. The main discrepancy comes from the fact that, in the ex-post calibration, import sanctions and financial shocks are larger and more persistent, while the domestic recession is shorter-lived, which explains the finer differences in magnitudes in the two panels.

Both panels of Figure 5 reveal that the role of different shocks changes significantly over time. In particular, we find that capital outflows driven by the financial shock ψ_t were the key driver behind the sharp depreciation of the ruble in the first weeks. Furthermore, the ex-post calibration in panel (b) reveals that the depreciation of the exchange rate would have been 10% larger if the central bank did not sell foreign reserves to satisfy the increased demand for foreign currency. In contrast, despite the large amount of FX reserves frozen by sanctions, the impact of this freeze on the value of the exchange rate is small (albeit very persistent) and generates a permanent 3% depreciation of the exchange rate (see panel a). Indeed, a permanent income loss from an asset freeze worth 100% of annual exports corresponds to a permanent reduction of export flows of about 4%, *i.e.* the annual rate of interest. Nonetheless, the FX freeze and sanctions on the Central Bank likely constrained its ability to fully accommodate the financial shock with unrestricted FX interventions (*cf.* Proposition 4 and Figure O2e in Appendix D).

38. While we do not extend the sample further, the ruble exchange rate has stabilized around 95 rubles per dollar, close to the long-run prediction of our ex-ante model equal to 92 against the pre-war level of 75.

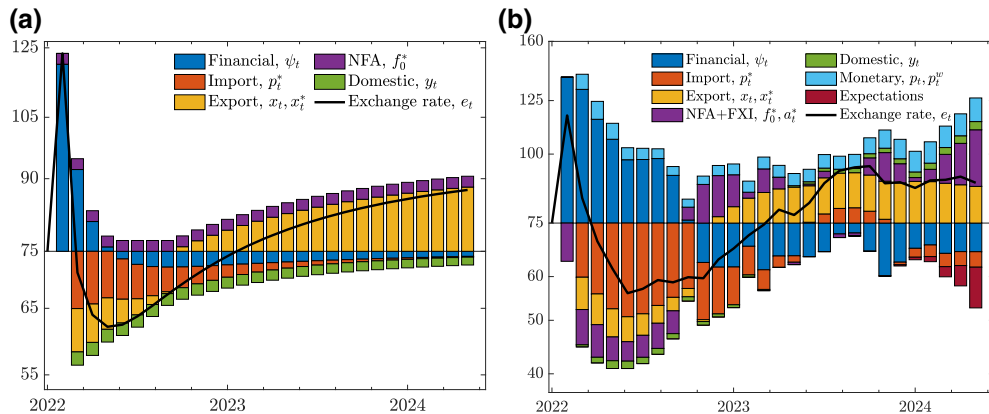


FIGURE 5

Exchange rate decomposition. (a) Ex-ante calibration and (b) Ex-post calibration

Note: The figures show with solid black lines the simulated path of the exchange rate (in levels) and with coloured bars the contribution of each shock according to the model with ex-ante calibration (panel a) and ex-post calibration that by construction reproduces dynamics of the exchange rate and macro variables (panel b; "Expectations" summarize the contribution of all future shocks after the last period in the sample)

One month out, trade shocks begin to dominate the dynamics of the exchange rate. First, trade restrictions that result in higher effective import prices and a decline in import quantities curb demand for foreign currency and act as a major ruble appreciation force in summer 2022. Second, the increase in energy prices and Russian export revenues in the first months after the invasion increase supply of foreign currency and also contribute to the appreciation of the currency. Finally, a contraction in domestic consumption also reduces import demand and contributes to the strengthening of the ruble, although this effect is quantitatively small. All in all, the combined effect neutralizes the surge in financial demand for foreign currency and, consistent with Propositions 1 and 2, explains the appreciation of the ruble from the third month onward.

Over time, import prices mean revert and import quantities recover as parallel imports and new trade linkages are established, resulting in a rebound in foreign-currency demand and an exchange rate depreciation. At the same time, the inflow of foreign currency contracts as commodity export revenues decline. Combined together, these forces bring the exchange rate back to the pre-war level about one year after the start of the war with a continued gradual depreciation thereafter. This trend is exacerbated by the government policy to rebuild the FX reserves starting in the end of 2022. The eventual decline in export revenues dominates in the long run, both in the ex-ante and ex-post calibrations, and the ruble ultimately depreciates by around 20% relative to its pre-war level. Finally, note the contribution of monetary accommodation (inflation) which results in additional nominal depreciation, albeit small (see panel b; not featured in the ex-ante calibration).

In sum, we find that the dynamics of the exchange rate is primarily shaped by the balance of financial shocks and trade restrictions, with the financial shock having a sharper effect in the very short run, and import and export sanctions dominating in the medium and long run. Speculatively, the particular mix of sanctions—that were concentrated on curbing Russian imports without curbing Russian export revenues boosted by high energy prices—allowed the government to avoid a full-scale currency and banking crises.

Robustness. Appendix Figure A1 displays two alternative calibrations. In the left panel, we show that replacing the assumption of perfect foresight with the assumption of martingale shocks, that is, with agents being surprised each period with the additional innovation to shocks, does not qualitatively change the prediction of the model about the contributions of shocks to the exchange rate dynamics. The reason is the combination of the persistence of calibrated shocks and the endogenous propagation of the responses to shocks in our model. Indeed, in a Ricardian model with $\kappa = 0$ in (3), financial shocks have no effect on allocation or the exchange rate, while trade sanctions result in an immediate permanent-income adjustment with no further dynamics, as we show in the right panel of Appendix Figure A1. In contrast, under the calibrated value of $\bar{\kappa} > 0$, the equilibrium consumption and the exchange rate respond more to contemporaneous shocks than to expected future shocks, a property our model shares with a large class of non-Ricardian models (cf. Auclert *et al.*, 2024; Angeletos *et al.*, 2024).

Validation of financial shocks. In the ex-post calibration of the model, the financial currency demand shock ψ_t is backed out as a residual to match the empirical path of the exchange rate. In Appendix E, we introduce two additional data series that allow us to validate the recovered financial shock process. The first series is the foreign-currency (euro) interest rate spread in Russia which we interpret as the premium to compel households to hold their savings domestically rather than taking them abroad as a result of the FX demand shock. This spread spikes after the start of the war and stays elevated for the next several months before coming down after mid-2022 and staying suppressed thereafter, in line with the dynamics of the component of the exchange rate induced by the calibrated ψ_t shock, as we show in Figure O3 in Appendix E.

Perhaps more importantly, we show that the calibrated ψ_t shock allows the model to track the sudden stop in capital flows to Russia captured by the collapse in external liabilities. In particular, we show that there is a spike in capital outflows after the start of the war which slowly reverts over the next year. When we interpret ψ_t as the decline in foreigners' demand for financial investments in Russia, the model reproduces accurately the additional data on gross capital flows, in addition to net capital flows that are matched by virtue of fitting the trade balance. Conversely, when we back out the path of ψ_t shock by matching exactly the dynamics of gross external liabilities without targeting the exchange rate, the model still captures well the empirical path of the exchange rate. We report these results in the two panels of Figure O4 in Appendix E.

4.2. Fiscal revenues, inflation and welfare

What was the ultimate effect of sanctions on the Russian economy and on the rest of the world? To answer this question, this subsection goes beyond the exchange rate and discusses the dynamics of other macroeconomic variables, using the ex-post calibration of the model.

Consider first fiscal revenues that, in our model, are proportional to nominal GDP.³⁹ The left panel of Figure 6 shows the aggregate revenues (black line) and its decomposition into different shocks. The initial depreciation of the exchange rate *boosts* local-currency revenues by 12% and this is further amplified by greater export revenues starting in the second month. These effects are offset in the medium run as a result of the exchange rate appreciation due to trade sanctions, and also by lower tax revenues because of the recession in the domestic economy. Nominal fiscal

39. As in the theory sections, we focus on the revenues of the consolidated budget abstracting from a disproportionately large contribution of energy exports to Russian federal budget (40% against 25% share in GDP) and a significant rise in government expenditures driving the fiscal deficit.

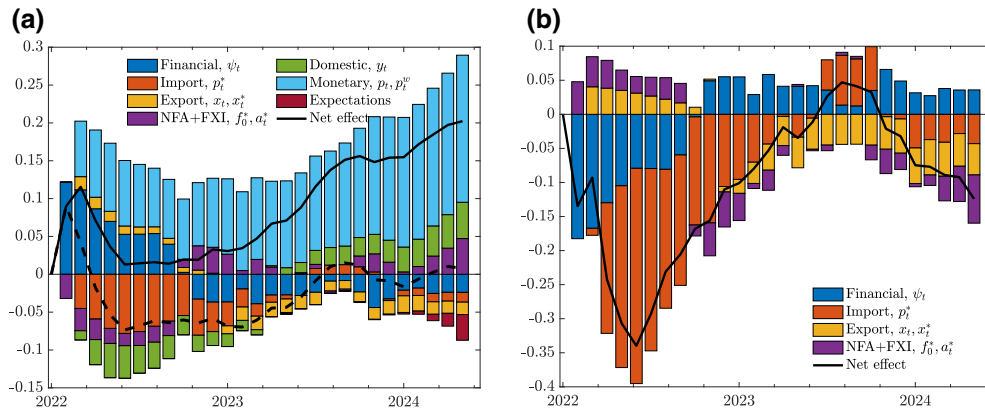


FIGURE 6

Fiscal and welfare implications. (a) Fiscal revenues and (b) Home welfare

Note: The figure shows a simulated response of government revenues (or equivalently nominal GDP, panel a) and home welfare (or equivalently real consumption, panel b) in log-percentage changes relative to the pre-war level (the black line) and their components driven by different shocks (coloured bars). The dashed black line in the left panel shows the real effect (equal to the solid line net of monetary component). “Expectations” summarize the contribution of all shocks after the last period in the sample; panel b only shows welfare effects of trade and financial sanctions

revenues, nonetheless, stay positive and even increase over time because of monetary inflation that builds up to 20% over the period. Once this component is excluded, the net *real* income (relative to the pre-war level) turns negative starting from April 2022 and remains mostly below zero after that (the dashed black line in the figure). The long-run real losses are close to zero because the exchange rate depreciation and the recovery of home production offset losses due to the reduction in foreign-currency exports. Excluding the contribution of domestic output, which arguably mirrors government war expenditure, we establish that international sanctions decrease the long-run real government revenues and national income by about 4%.

Zooming in on the welfare implications of sanctions, the right panel of Figure 6 shows the effects of trade and financial shocks on aggregate consumption.⁴⁰ In line with Proposition 4, the capital outflows shock ψ_t that is not fully offset by FX interventions in the first months results in a ruble depreciation and makes domestic households cut their consumption of foreign goods. Because financial shocks generate intertemporal substitution without changing the country’s resource constraint, their negative short-run effects are largely transitory and offset in the medium and long run. In contrast, the decline in real imports driven by trade restrictions is the main source of welfare losses with import sanctions dominating in the medium run and export sanctions explaining most of the long-run dynamics. The corresponding welfare losses in terms of a decline in real consumption during the sample period are equal to 7% and 1.8% for import and export sanctions, and 0.6% for the net foreign asset freeze combined with changes in FX reserves.⁴¹ The combined effect from 2.5 years of sanctions also corresponds to a *permanent* decline in consumption by 0.9%, vastly larger than the conventional estimates of the cost of a business cycle. While the effect is largely front-loaded in the figure, the decline in consumption

40. We exclude from the analysis changes in domestic production that are largely unrelated to foreign sanctions.

41. Note that our definition of export sanctions incorporates the positive short-run effect from increased commodity prices, as can be seen in Figure 6b.

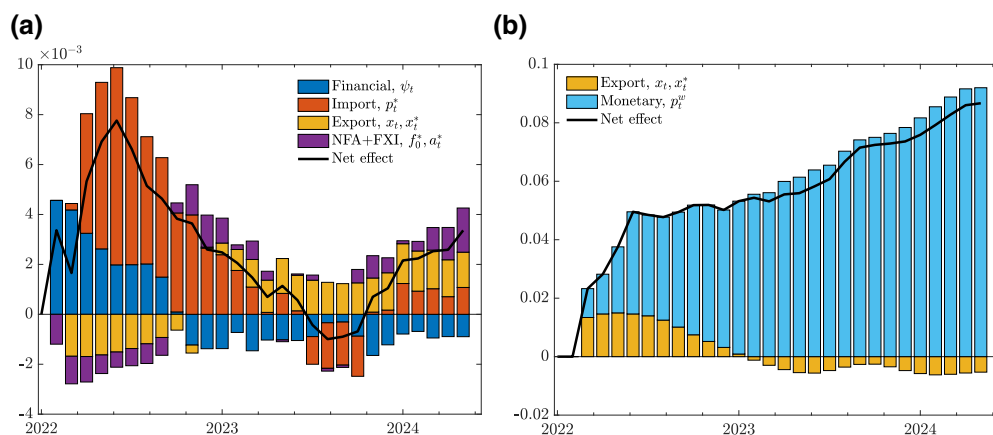


FIGURE 7

Effects of sanctions on the rest of the world. (a) Foreign welfare and (b) Foreign CPI.

Note: The figure shows simulated welfare (or, equivalently, real consumption, in panel a) and consumer price index (in panel b) in the rest of the world in log-percentage changes relative to the pre-war level (black lines) and their components driven by different shocks (coloured bars)

and welfare is likely to be more gradual and muted in practice because of the pre-war stockpile of durables and inventories of imported goods.

The welfare dynamics is also closely related to CPI inflation. Indeed, equation (13) shows that consumer prices are inversely proportional to import quantities c_{Ft} and depend also on local production y_t and monetary inflation p_t . This explains why the dynamics of the consumer price index, shown in Appendix Figure A2, tracks to a large extent the dynamics of welfare in Figure 6, but with the opposite sign and augmented by monetary shocks. As with import quantities, the model likely overstates the short-run pass-through of border prices into consumer prices, both due to sticky retail prices and the stockpile of imported inventories.

Rest of the world. Our analysis sheds light on the welfare implications for the sanctioning coalition. Consistent with our findings in Section 3.2, the freeze of foreign assets, import tariffs, and financial shocks act as a positive transfer from the home economy to the rest of the world. As a result, the welfare effects of these shocks on foreign welfare is the same as on home welfare, but with the opposite sign and smaller in magnitude. The net effect is positive throughout most of the period and equivalent to 0.2% increase in annual consumption during this period, as we show in the left panel (a) of Figure 7.

In contrast, export sanctions that are imposed in the form of quantity restrictions rather than tariffs also change the supply of commodities to the rest of the world resulting in higher energy prices, lower energy consumption, and welfare losses. Recall that our calibration infers the path of export quantities from the path of Russian export revenues and the world commodity prices. The implied decline in these quantities results in the welfare losses in the rest of the world during 2022, which are eliminated starting in 2023 due to higher energy supply within the rest of the world. We find that the net effect on the rest of the world from all economic sanctions combined is close to zero. This calculation does not factor in the direct military and economic costs of the war.

These estimates also do not take into account the indirect effect of sanctions-induced inflation that can lead to monetary tightening and additional output losses under sticky prices.⁴² While such analysis goes beyond the scope of this paper, the right panel (b) of Figure 7 shows that a rise in energy prices due to export sanctions increases foreign consumer prices by about 1% in the first months, explaining half of the overall inflation in that period. Just like with welfare, the inflationary effects of sanctions dissipate starting in 2023, in line with the evidence of fast substitution in the world energy market (see *e.g.* Moll *et al.*, 2023).

5. CONCLUSION

A record number of economic sanctions have been imposed on the Russian economy since the invasion of Ukraine in February 2022. Given that it might take months or even years for these restrictions to take the toll on the economy, many commentators and policymakers attempted to infer the effects of sanctions from the contemporaneous dynamics of the ruble exchange rate. Building on recent models of equilibrium exchange rate determination, this paper clarifies the relationship between sanctions, exchange rates, government revenues and welfare.

We show theoretically that all forms of trade sanctions tend to reduce economic welfare by means of tightening the country budget constraint—whether by reducing the sources of income or by increasing the costs of imports—and this equivalence also extends to government fiscal revenues. However, the implications for the equilibrium exchange rate are polar opposite. While import sanctions trigger a trade and currency surplus and require an exchange rate appreciation to rebalance the goods and currency markets, export and foreign asset sanctions reduce the inflow of foreign currency and lead to a depreciation. Thus, even though the exchange rate is allocative and responds to sanctions, it is not a sufficient statistic to judge the economic impact. We also show that financial sanctions that increase private FX demand—either for domestic savings or as a result of capital outflows—can be fully offset with FX interventions which eliminate the impact on the exchange rate and imports. Otherwise, the central bank faces an unpleasant trade-off between depreciating the currency and distorting imports or using financial repression to suppress household demand for FX savings.

A simple quantitative model provides a surprisingly good out-of-sample fit and reconciles the seemingly puzzling swings in the exchange rate with the collection of sanctions imposed on Russia and their dynamics over time. Among intriguing questions left for future research is the missing financial crisis in Russia in spring 2022, despite unprecedented financial sanctions and a sharp exchange rate devaluation in the first weeks of the war. The combination of a large trade surplus, a fiscal surplus, and no domestic contract dollarization was likely the reason why the Bank of Russia managed to fend off a full-scale financial crisis with a steep increase in the ruble policy rate and a battery of financial repressions, including a ban on withdrawal of foreign currency deposits. However, the relative contribution of these factors is less clear. In particular, it is unclear whether the economy was in the region of multiple equilibria and managed to navigate away from a crisis equilibrium or whether an alternative sanctions policy—*e.g.* focussed on curbing export revenues rather than restricting imports—could have eliminated the existence of the no-crisis equilibrium.

42. While the optimal monetary policy targets only prices that are sticky in local currency, it does respond to higher prices of imported commodities whenever the latter are used as inputs in production (Egorov and Mukhin, 2023). We quantify inflation in the rest of the world as $\Delta \log P_t^* = (1 - \gamma^*) \Delta \log P_t^w + \gamma^* \Delta \log Q_t^w$, where γ^* is the steady-state share of commodities in total expenditure.

APPENDIX: ADDITIONAL DISPLAYS

TABLE A1
Ex-ante calibration of shocks

	Financial		Import	Export		Domestic
	f_0^*, a_0^*	ψ_t	p_t^*	Temp., x_t	Perm., x_t^*	output, y_t
Initial shock, ε_{t_0}	-12	1.5	0.5	0.5	-0.3	-0.05
– arrives in period, t_0	0	0	1	1	1	1
Persistence, ρ	1	0.94	0.84	0.92	1	0.98
– half life (months)	∞	12	4	8	∞	36

Note: For each shock, the table shows calibrated values of the initial innovation ε_{t_0} , the period when the shock arrives t_0 , as well as persistence (autocorrelation) and corresponding half lives. All shocks follow AR(1) processes. Export revenues, $ex_t = q_t^* + x_t = -\frac{\bar{s}-\eta}{\eta} x_t - \frac{1-\bar{s}}{\eta} x_t^*$, combine a permanent shock $x_{t_0}^* = 0.3 \frac{\eta}{1-\bar{s}}$ and a temporary shock $x_{t_0} = -0.5 \frac{\eta}{\bar{s}-\eta}$. The values of financial shocks are expressed in terms of steady-state monthly imports, while all other shocks are expressed in proportional changes (log point deviations from the initial steady state values).

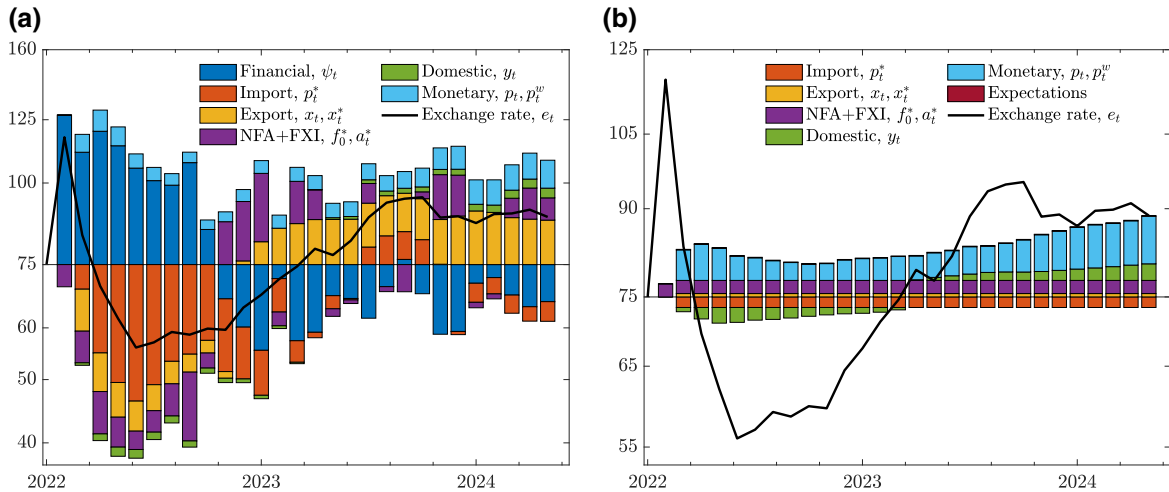


FIGURE A1

Alternative ex-post calibrations. (a) Unexpected shocks and (b) $\bar{\kappa} = 0$

Note: The figure shows the simulated path of the exchange rate (solid black lines) and the contribution of each shock (colored bars) according to the model with ex-post calibration similar to the one shown in Figure 5b. Panel a replaces a perfect foresight assumption with shocks following a random walk (each period featuring a surprise change; see Appendix D) and panel b considers an alternative calibration with $\bar{\kappa} = 0$ (a Ricardian model with a permanent-income response to all shocks). Note that with $\bar{\kappa} = 0$, financial shocks play no role and trade shocks result in a random-walk-like impulse responses, hence the model cannot match the dynamics of the exchange rate.

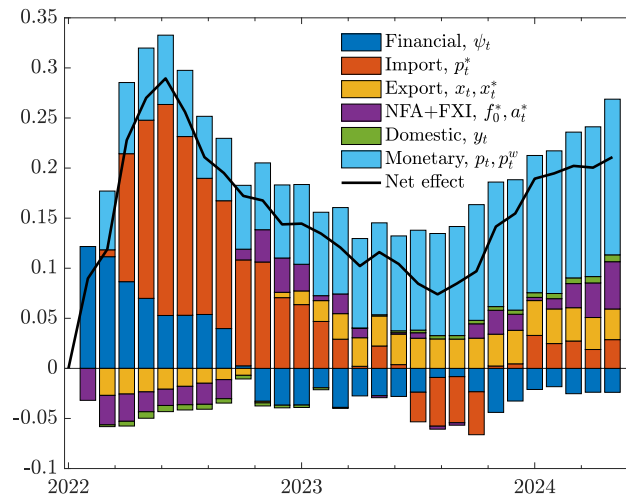


FIGURE A2

Inflation

Note: The figure shows a simulated response of consumer price index in log-percentage changes relative to the pre-war level (the black line) and its components driven by different shocks (colored bars). “Expectations” summarize the contribution of all shocks after the last period in the sample

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Supplementary Data

Supplementary data are available at [Review of Economic Studies](#) online.

Data availability

The data and code underlying this article are available at <https://doi.org/10.5281/zenodo.16753406>.

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